Postpartum phytomedicine and its future in maternal healthcare in Prey Lang, Cambodia

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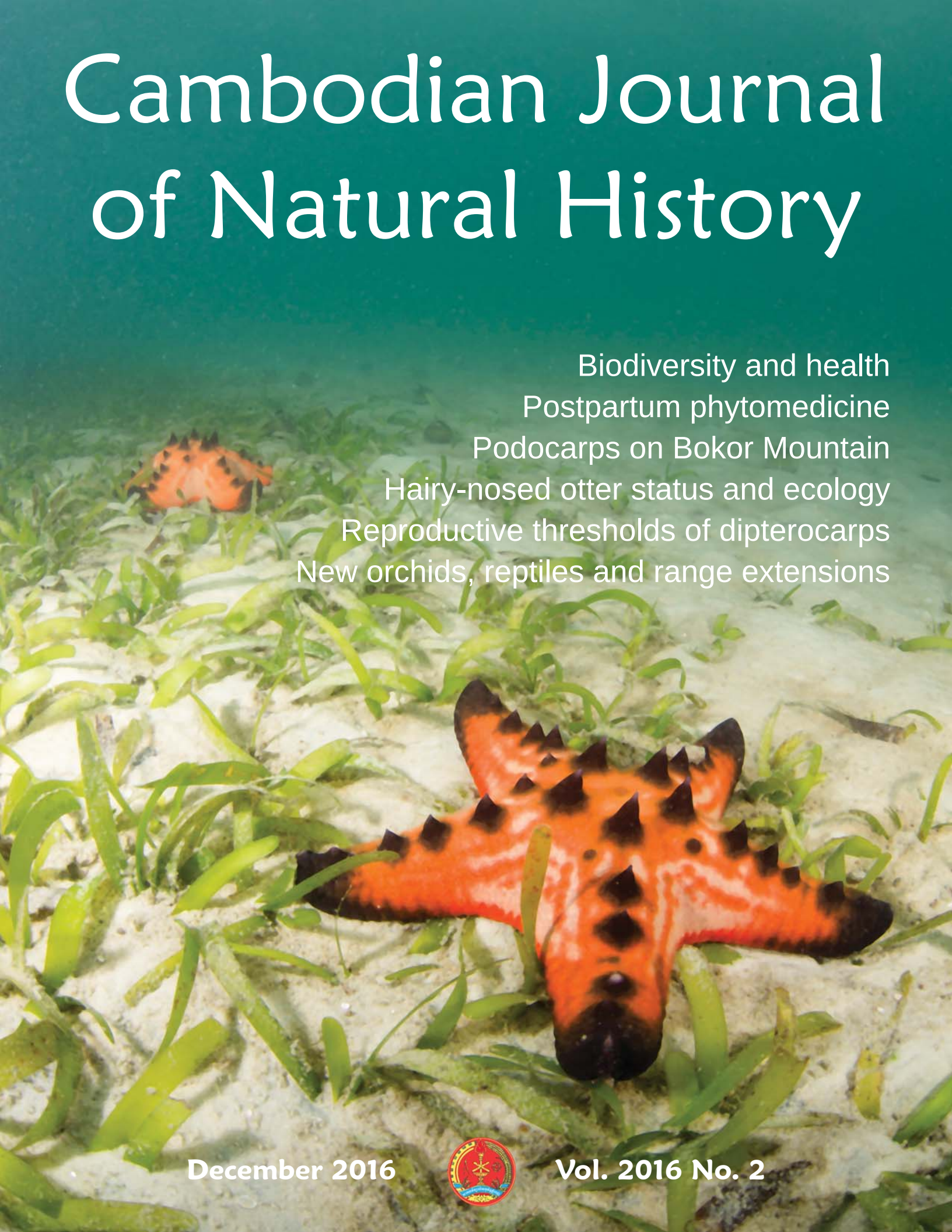

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Cover image: Chocolate chip seastars (*Protoreaster nodosus*) in a seagrass meadow near Koh Rong Island (© Paul Colley). The Royal Government of Cambodia declared the country's first large-scale marine protected area around the islands of Koh Rong and Koh Rong Sanloem in June 2016 (page 83).

Editorial — Links between biodiversity and health: consequences and opportunities for collaboration

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The relationships between biodiversity and the health of people, livestock, and wildlife have been increasingly recognized and documented in recent decades (Millennium Ecosystem Assessment, 2005; Myers *et al.,* 2013; Hough, 2014; WHO, 2015). In attempting to understand the practical implications of these links, one inevitably stumbles on their complexity and sometimes contradictory nature. One consequence of this is difficulty in aligning the policy agendas and activities of the conservation and health sectors (Chivian & Bernstein, 2008; Hough, 2014). In the interests of promoting beneficial collaborations between these sectors, we briefly illustrate the diversity of these relationships using examples from Cambodia, and highlight the complementary nature of conservation and health initiatives through examples of ongoing projects and potential opportunities.

Strong economic growth in Cambodia, with a stable 7% GDP growth over the past six years, has led to improvements in several development and health indicators (World Bank, 2016). However, rapid rates of deforestation, agricultural growth, and urbanization represent major challenges to ecosystem and biodiversity conservation, and offer mixed prospects for animal and public health (NBSC, 2014).

One of the most obvious connections between biodiversity and health is through *provisioning services* (Millennium Ecosystem Assessment, 2005). Many of Cambodia's rural communities still rely heavily on wildlife and non-timber forest products for their subsistence and nutritional needs, similar to other parts of Southeast Asia and the world (Golden *et al.,* 2011; Johnson *et al.,* 2012). However, wildlife consumption has also caused major infectious disease outbreaks (e.g., SARS, HIV, Ebola) and continues to be a driver of disease emergence (Karesh & Noble, 2009; Greatorex *et al.,* 2016). Overfishing and overhunting are also driving biodiversity declines in many of Cambodia's landscapes (Valbo-Jørgensen *et al.,* 2009; Gray et al., 2012), further affecting food chains in these ecosystems and compromising the nutritional status and survival of wildlife (O'Kelly *et al.,* 2012). Conversion of biodiverse areas to monocultures and agriculture intensification have increased chemical pollution with severe health consequences for wildlife, livestock, and humans (Monirith *et al.,* 1999; Neufeld *et al.,* 2010; Wang *et al.,* 2011; WCS, 2016). Smoke from forest fires used to clear land also cause significant respiratory issues, particularly in children (Jayachandran, 2009). When natural habitats are destroyed, the vegetal and microbial diversity that have allowed many biomedical discoveries supporting human and animal health (e.g., anti-microbial drugs) are also lost. These biota also support the health of rural and indigenous communities through traditional medicine (Hout *et al.,* 2006; Chea *et al.,* 2007). Although conservation of medicinal plants can be used to promote sustainable use and forest protection (e.g., Laval *et al.,* 2011), some of the beliefs and practices involving the use of animal parts for traditional medicine pose a considerable threat to wildlife (Sodhi *et al.,* 2004; Starr *et al.,* 2010) and will likely continue to result in species extinctions (Courchamp *et al.,* 2006).

A wide range of *regulating and supporting ecosystem services* (Millennium Ecosystem Assessment, 2005) are related to wildlife, livestock, and human health. Intact ecosystems may help in regulating pests and infectious diseases (WHO, 2015). However, the relationships between biodiversity and infectious diseases are complex, highly context-dependent, and much debated (Johnson & Thieltges, 2010; Randolph & Dobson, 2012; Ostfeld, 2013). In some circumstances, diversity of host species plays a regulating role through the combined

action of host competition and differential host susceptibility to pathogens (i.e. the dilution effect) (Keesing *et al.,* 2010), while in others, it can be a source of pathogens and result in their amplification (Randolph & Dobson, 2012). Higher biodiversity often results in higher pathogen diversity, but a pathogen-rich ecosystem may not necessarily be an issue; rather it is the loss of ecosystem integrity and increased contact with invasive hosts (including humans and livestock) that may increase disease emergence risks (Patz *et al.,* 2004). For instance, the overall richness of infectious diseases in the Asia-Pacific region is positively correlated with the richness of birds and mammals, but the number of zoonotic disease outbreaks are positively correlated with the number of threatened wildlife species, while vector-borne disease outbreaks are negatively correlated to the percentage of forest cover (Morand *et al.,* 2014). Encroachment into natural areas, logging and road development, increased contact between wildlife, livestock and humans, and modification of host and vector communities are some of the factors linking ecosystem disturbance to disease emergence (Horby *et al.,* 2013; Jones *et al.,* 2013). Threats of disease emergence are by no means limited to humans and livestock, and their consequences for wildlife conservation can be dire. Large epidemics of chytrid fungus in amphibians and canine distemper virus in wild carnivores, for instance, are driving declines in many species (Hatcher *et al.,* 2012; Kolby & Daszak, 2016). In Cambodia, there is still much to learn about how infectious diseases may challenge conservation efforts, and the current interest in wildlife farming (intended to reduce hunting pressure on wild populations) is likely to create more interfaces that increase the risk of disease emergence (WCS & FPD, 2008). Finally, most regulating or supporting ecosystem services have direct or indirect impacts on animal and human health at various scales. Water and nutrient cycles, carbon sequestration, and pollination all have complex relationships with factors that influence pathogen transmission, nutrition and other health outcomes. Exposure of humans to biodiverse environments has also been linked to the ability to mount adequate immune response and prevent autoimmune diseases (WHO, 2015). The social and psychological impact of habitat degradation on society is also increasingly documented (Speldewinde *et al.,* 2009), as is the positive effect of experiencing nature on mental and physical well-being (Bratman *et al.,* 2012).

Given the diverse relationships between biodiversity and health, any policy or intervention directed to one sector will inevitably affect the other (Walther *et al.,* 2016). In recognition of the complex connections between the environment, wildlife, livestock, humans and pathogens, the concepts of "One Health", "EcoHealth" and "Planetary Health" have emerged to promote integrative and trans-disciplinary approaches to their study (Roger *et al.,* 2016). These are all initiatives and frameworks that foster collaboration between the livestock, human and wildlife health sectors, and encourage an ecosystem approach to health. Although these efforts have improved coordination between public and animal health, much more can be done to increase collaboration between health sectors and conservation initiatives.

Field personnel in protected areas and individuals that directly work with wildlife (e.g., law enforcement, wildlife monitoring) are typically at the forefront of unusual events in wildlife and constitute an important interface with wild animals and the pathogens they carry. Such field capacity is invaluable for wildlife health surveillance. Biodiversity monitoring is in many cases a powerful indicator of health-related factors (e.g., lichens and air quality, arthropods and soils, aquatic organisms and aquatic systems) (WHO, 2015). Disease outbreak and mass mortalities in wildlife can also provide a warning sign for health issues in livestock and humans, irrespective of whether the origin is infectious (e.g., West-Nile virus, Yellow fever, Ebola) or non-infectious. The latter is illustrated by the recent detection of wildlife deaths in Preah Vihear Province from pesticide contamination of the environment, also affecting livestock and humans (WCS, 2016). An important consequence is that staff working in protected areas need to understand the risks of zoonotic disease transmission and other health risks, and to adopt adequate protective measures in their activities. Collaboration between conservation and health organizations could do much to improve detection of these events and ensure prompt identification of the underlying issues and appropriate responses. This is currently being done under a EU-funded LACANET (Lao PDR – Cambodia One Health Network) project which links field capacity and wildlife health expertise (within the Wildlife Conservation Society) with animal and public health partners, and trains staff in Cambodia's protected areas to organize wildlife health surveillance (LACANET, 2016). The project is also conducting research on the factors that are driving biodiversity loss and disease emergence (e.g., land-use change, wildlife trade). This presents an opportunity to address conservation challenges in a new way, as health is a value broadly shared across cultural and socio-economic groups, and can be used to generate support for conservation initiatives when overlapping objectives are identified. In addition, many conservation NGOs have long-standing relationships with local communities and particular landscapes, which makes them particularly well-positioned to facilitate health-related projects and interven-

tions. Engagement on health issues could also strengthen these ties. Conservation organizations should include health as one of their conservation tools, and reach out to health organizations to identify potential collaborations. In a resource-limited context, it is also imperative to optimize the use of resources, and take advantage of these potential synergies. This includes the appropriate use of wildlife by limiting the use of lethal sampling for health studies, and collaborating with local collections (such as the zoological collection of the Centre for Biodiversity Conservation at the Royal University of Phnom Penh [RUPP]) and bio-banking efforts (such as the RUPP Conservation Genetics laboratory) when wildlife mortality is beyond the control of project implementers.

The complementarity of the conservation and health sectors should be better utilized as part of the multiple projects that follow the "One Health" framework (i.e. multi-disciplinary ecosystem approach to health), and could improve assessments of the respective impacts of health and conservation interventions on conservation and health outcomes. For instance, when community access to wildlife is critical to maintain nutrition in protected areas, but no longer acceptable due to population declines, conservation organizations could seek the support of animal production and animal health partners to find alternative strategies addressing such issues. Similarly, disease risks related to wildlife consumption, when appropriately documented, may also be a strong argument to encourage reductions in wildlife hunting and trade, and the health sectors should work closely with conservation partners to translate findings into useful outreach material. Additionally, because strategies used by conservationists in Cambodia are diversifying (e.g., the Wildlife Conservation Society and Fauna & Flora International support the recovery of wild populations of Mangrove Terrapin (*Batagur affinis*) and Siamese crocodile (*Crocodylus siamensis*) through headstarting, captive breeding and reintroduction, whereas BirdLife International use livestock to perform the ecological roles once played by large ungulate populations in Western Siem Pang), needs for expertise in veterinary care, animal health and husbandry must be appropriately assessed to ensure the health and well-being of the animals, and ultimately the success of these efforts. Consultation with appropriate animal health expertise at the planning stage is therefore essential, as reactive measures usually come too late to adequately identify and address underlying issues. Similarly, although many wildlife health projects in Cambodia in recent years have been implemented under the One Health umbrella, their links to conservation have often been an after-thought. Maintaining a dialogue between wildlife health and conservation actors is essential to ensure that the wildlife health activities also meet questions and needs related to species conservation, and identifies these during the onset of projects.

In short, improving collaboration between conservationists and practitioners from the human, livestock and wildlife health sectors is critical. Joint planning should aim at identifying complementarity and aligning objectives, and organize coordinated activity implementation and integrated actions. This is not only a morally responsible use of resources, but is also necessary to harness synergies that already exist in nature.

References

Bratman, G.N., Hamilton, J.P. & Daily, G.C. (2012) The impacts of nature experience on human cognitive function and mental health: nature experience, cognitive function, and mental health. *Annals of the New York Academy of Sciences*, **1249**, 118–136.

Chea A., Jonville, M.-C., Bun S.-S., Laget, M., Elias, R., Duménil, G. & Balansard, G. (2007) In vitro antimicrobial activity of plants used in Cambodian traditional medicine. *American Journal of Chinese Medicine*, **35**, 867–873.

Chivian, E. & Bernstein, A. (eds) (2008) *Sustaining Life: How Human Health Depends on Biodiversity*. Oxford University Press, Oxford, UK.

Courchamp, F., Angulo, E., Rivalan, P., Hall, R.J., Signoret, L., Bull, L. & Meinard, Y. (2006) Rarity value and species extinction: the anthropogenic allee effect. *PLoS Biology*, **4**, e415. doi: 10.1371/journal.pbio.0040415

Golden, C.D., Fernald, L.C.H., Brashares, J.S., Rasolofoniaina, B.J.R. & Kremen, C. (2011) Benefits of wildlife consumption to child nutrition in a biodiversity hotspot. *Proceedings of the National Academy of Science*, **108**, 19653–19656.

Gray, T.N.E., Phan C., Pin C. & Prum S. (2012) Establishing a monitoring baseline for threatened large ungulates in eastern Cambodia. *Wildlife Biology*, **18**, 406–413.

Greatorex, Z.F., Olson, S.H., Singhalath, S., Silithammavong, S., Khammavong, K., Fine, A.E., Weisman, W., Douangngeun, B., Theppangna, W., Keatts, L., Gilbert, M., Karesh, W.B., Hansel, T., Zimicki, S., O'Rourke, K., Joly, D.O. & Mazet, J.A.K. (2016) Wildlife trade and human health in Lao PDR: an assessment of the zoonotic disease risk in markets. *PloS One*, **11**, e0150666. doi: 10.1371/journal.pone.0150666

Hatcher, M.J., Dick, J.T.A. & Dunn, A. (2012) Disease emergence and invasions. *Functional Ecology*, **26**, 1275–1287.

Horby, P.W., Pfeiffer, D. & Oshitani, H. (2013) Prospects for emerging infections in East and Southeast Asia 10 years after severe acute respiratory syndrome. *Emerging Infectious Diseases,* **19**, 853–860.

Hough, R.L. (2014) Biodiversity and human health: evidence for causality? *Biodiversity Conservation,* **23**, 267–288.

Hout S., Chea A., Bun S.-S., Elias, R., Gasquet, M., Timon-David, P., Balansard, G. & Azas, N. (2006) Screening of selected indigenous plants of Cambodia for antiplasmodial activity. *Journal of Ethnopharmacology*, **107**, 12–18.

Jayachandran, S. (2009) Air quality and early-life mortality evidence from Indonesia's wildfires. *Journal of Human Resources*, **44**, 916–954.

Johnson, A., Krahn, J., Seateun, S., Phoumkhamouane, S., Inthavixay, C. & Phanmathong, K. (2012) *Linking sustainable harvest of managed wildlife and household food consumption in the Nam Et-Phou Louey National Protected Area*. Unpublished report to Wildlife Conservation Society, Vientiane, Laos.

Johnson, P.T. & Thieltges, D.W. (2010) Diversity, decoys and the dilution effect: how ecological communities affect disease risk. *Journal of Experimental Biology*, **213**, 961–70.

Jones, B.A., Grace, D., Kock, R., Alonso, S., Rushton, J., Said, M.Y., McKeever, D., Mutua, F., Young, J., McDermott, J. & Pfeiffer, D.U. (2013) Zoonosis emergence linked to agricultural intensification and environmental change. *Proceedings of the National Academy of Science*, **110**, 8399–8404.

Karesh, W.B. & Noble, E. (2009) The bushmeat trade: increased opportunities for transmission of zoonotic disease. *The Mount Sinai Journal of Medicine*, **76**, 429–434.

Keesing, F., Belden, L.K., Daszak, P., Dobson, A., Harvell, C.D., Holt, R.D., Hudson, P., Jolles, A., Jones, K.E., Mitchell, C.E., Myers, S.S., Bogich, T. & Ostfeld, R.S. (2010) Impacts of biodiversity on the emergence and transmission of infectious diseases. *Nature*, **468**, 647–52.

Kolby, J.E. & Daszak, P. (2016) The emerging amphibian fungal disease, chytridiomycosis: a key example of the global phenomenon of wildlife emerging infectious diseases. *Microbiology Spectrum*, **4**, 1–17.

LACANET (2016) *Lao PDR-Cambodia One Health Surveillance and Laboratory Network*. Http://www.onehealthsea.org/lacanet [accessed 23 August 2016].

Laval, P., Rakotoarison, H., Savajol, N. & Vanny T. (2011) The contribution of wild medicinal plants towards poverty alleviation and health improvements: a case study in two villages in Mondulkiri Province, Cambodia. *Cambodian Journal of Natural History*, **2011**, 29–39.

Millennium Ecosystem Assessment (2005) *Ecosystems and Human Well-Being: Synthesis*. Island Press, Washington DC, USA.

Monirith I., Nakata H., Tanabe S. & Seang Tana, T. (1999) Persistent organochlorine residues in marine and freshwater fish in Cambodia. *Marine Pollution Bulletin*, **38**, 604–612.

Morand, S., Jittapalapong, S., Suputtamongkol, Y., Abdullah, M.T. & Huan T.B. (2014) Infectious diseases and their outbreaks in Asia-Pacific: biodiversity and its regulation loss matter. *PLoS ONE*, **9**, e90032. doi: 10.1371/journal.pone.0090032

Myers, S.S., Gaffikin, L., Golden, C.D., Ostfeld, R.S., Redford, K.H., Ricketts, T.H., Turner, W.R. & Osofsky, S.A. (2013) Human health impacts of ecosystem alteration. *Proceedings of the National Academy of Science*, **110**, 18753–18760.

NBSC (2014) *The fifth national report to the convention on biological diversity*. National Biodiversity Steering Committee, Phnom Penh, Cambodia.

Neufeld, D.S.G., Savoeun H., Phoeurk C., Glick, A. & Hernandez, C. (2010) Prevalence and persistence of organophosphate and carbamate pesticides in Cambodian market vegetables. *Asian Journal of Water Environment and Pollution*, **7**, 89–98.

O'Kelly, H.J., Evans, T.D., Stokes, E.J., Clements, T.J., An D., Gately, M., Nut M., Pollard, E.H.B., Men S. & Walston, J. (2012) Identifying conservation successes, failures and future opportunities; assessing recovery potential of wild ungulates and tigers in eastern Cambodia. *PLoS ONE*, **7**, e40482. doi: 10.1371/journal.pone.0040482

Ostfeld, R.S. (2013) A candide response to Panglossian accusations by Randolph and Dobson: biodiversity buffers disease. *Parasitology*, **140**, 1196–1198.

Patz, J.A., Daszak, P., Tabor, G.M., Aguirre, A.A., Pearl, M., Epstein, J., Wolfe, N.D., Kilpatrick, A.M., Foufopoulos, J., Molyneux, D., Bradley, D.J. & Members of the Working Group on Land Use Change Disease Emergence (2004) Unhealthy landscapes: policy recommendations on land use change and infectious disease emergence. *Environmental Health Perspectives*, **112**, 1092–1098.

Randolph, S.E. & Dobson, A.D.M. (2012) Pangloss revisited: a critique of the dilution effect and the biodiversity-buffers-disease paradigm. *Parasitology*, **139**, 847–863.

Roger, F., Caron, A., Morand, S., Pedrono, M., de Garine-Wichatitsky, M., Chevalier, V., Tran A., Gaidet, N., Figuié, M., de Visscher, M.-N. & Binot, A. (2016) One Health and EcoHealth: the same wine in different bottles? *Infection Ecology and Epidemiology*, **6**. doi: 10.3402/iee.v6.30978

Sodhi, N.S., Koh, L.P., Brook, B.W. & Ng P.K.L. (2004) Southeast Asian biodiversity: an impending disaster. *Trends in Ecology & Evolution*, **19**, 654–660.

Speldewinde, P.C., Cook, A., Davies, P. & Weinstein, P. (2009) A relationship between environmental degradation and mental health in rural Western Australia. *Health Place*, **15**, 880–887.

Starr, C., Nekaris, K.A.I., Streicher, U. & Leung, L. (2010) Traditional use of slow lorises *Nycticebus bengalensis* and *N. pygmaeus* in Cambodia: an impediment to their conservation. *Endangered Species Research*, **12**, 17–23.

Valbo-Jørgensen, J., Coates, D. & Hortle, K. (2009) Fish diversity in the Mekong River Basin. In *The Mekong – Biophysical Environment of an International River Basin* (ed I.C. Campbell), pp. 161–196. Elsevier, New York, USA.

Walther, B.A., Boëte, C., Binot, A., By Y., Cappelle, J., Carrique-Mas, J.J., Chou M., Furey, N., Kim S., Lajaunie, C., Lek S., Méral, P., Neang M., Huan T.B., Walton, C. & Morand, S. (2016) Biodiversity and health: lessons and recommendations from an interdisciplinary conference to advise Southeast Asian research, society and policy. *Infection, Genetics and Evolution*, **40**, 29–46.

Wang H.-S., Sthiannopkao, S., Du J., Chen Z.-J., Kim K.-W., Mohamed Yasin, M.S., Hashim, J.H., Wong C.K.-C. & Wong M.-H. (2011) Daily intake and human risk assessment of

organochlorine pesticides (OCPs) based on Cambodian market basket data. *Journal of Hazardous Matererial*, **192**, 1441–1449.

WCS (2016) *Carbofuran poisoning at the interface between wildlife, livestock, and humans*. Unpublished report to Wildlife Conservation Society, Phnom Penh, Cambodia.

WCS & FPD (2008) *Commercial wildlife farms in Vietnam: a problem or solution for conservation?* Wildlife Conservation Society and Vietnam Forest Protection Department, Hanoi, Vietnam.

World Bank (2016) *Cambodia Overview*. Http://www.worldbank.org/en/country/cambodia/overview [accessed 18 August 2016].

WHO (2015) *Connecting Global Priorities: Biodiversity and Human Health, A State of Knowledge Review*. Convention on Biological Diversity, United Nations Environment Programme & World Health Organization, Geneva, Switzerland.

News

Learning from observational data to improve protected area management

Hunting is a key driver of biodiversity loss, particularly in Southeast Asia where the illegal trade in wildlife is rife. To effectively prevent poaching, protected area (PA) managers require reliable, accurate information about poaching prevalence, poacher identities and behaviour. In many PAs managers rely on ranger-collected data and tools such as SMART to collect this information, monitor threats and plan law enforcement strategies. While ranger-collected data can provide important information, their potential can only be realised when biases inherent in the data collection process are properly accounted for. Recording of illegal activities is influenced by many factors, most importantly that the fundamental purpose of patrols is to change the behaviour of offenders. This makes the analysis of ranger-collected data extremely complex.

In January 2016 a research project entitled "Learning from observational data to improve PA management" was launched to improve the use of ranger-collected data for PA management. The project is funded by the UK's Natural Environment Research Council and is a three-year collaboration between scientists at the Universities of Edinburgh, Oxford and York in the UK and the Wildlife Conservation Society in Cambodia. An inception workshop was held in Phnom Penh and Keo Seima Wildlife Sanctuary (KSWS), Mondulkiri in May 2016 and was attended by government and NGO representatives. The project has two strands: 1) a modelling component simulating patrol and poacher behaviour to understand how patrol data can best be used to inform law enforcement strategies; 2) a fieldwork component based in KSWS which will investigate poaching prevalence and poacher decision-making, determine how patrol efforts affect snare detection rates and assess the factors that motivate rangers on patrol, and provide data to empirically validate our models. Our overall objectives are to create simple, practical rules of thumb to enable PA managers to accurately interpret their patrol data, and to provide specific information to support management of KSWS.

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Development of guidelines for wetland wise use in Cambodia

The Wildfowl and Wetlands Trust (UK) is working with the Department of Freshwater Wetlands Conservation in the Cambodian Ministry of Environment and BirdLife International (Cambodia) to develop "Guidelines for wetland wise use". The guidelines will appear in the form of a handbook for wetland site managers and other stakeholders and will include practical information on approaches and techniques that can be used to effectively manage wetlands for the benefit of people and biodiversity, specifically focussing on the issues and challenges that wetlands face in Cambodia.

To facilitate development of the guidelines, a consultation workshop was held in August 2016 at the Sunway Hotel in Phnom Penh. This was attended by over 40 participants, including representatives from the Cambodian Ministry of Environment and other government ministries, the Royal University of Phnom Penh, Panhasasra University and several NGOs. The workshop introduced the rationale behind the need for guidelines to promote wise use of wetlands in Cambodia, and provided an opportunity for stakeholders to discuss management challenges and important aspects that should be included in the guidelines.

Following the workshop, an accompanying study tour took place to Boeung Prek Lapouv Protected Landscape in Takeo Province, one of the largest remnants of seasonally-inundated grassland in the Lower Mekong region. The study tour acted as a learning experience, providing participants with an opportunity to see wetland management in practice. The trip also facilitated further discussions on wise uses of wetlands and its outcomes will be used to inform development of the guidelines.

Work has now begun on drafting the guidelines, with a draft due to be released for comments in January 2017. The effort is funded by the UK Government's Darwin Initiative and the Critical Ecosystem Partnership Fund.

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News

Cambodia's first large-scale marine protected area declared in the Koh Rong Archipelago

Cambodia achieved a landmark for national marine conservation on 16th June 2016 when the Ministry of Agriculture, Forestry and Fisheries signed a Prakas declaring a 405 km^2 Marine Fisheries Management Area (MFMA) around the islands of Koh Rong and Koh Rong Sanloem, the country's first large-scale marine protected area.

This internationally-recognised marine protected area will promote sustainable fishing through government leadership and community-driven action. The Cambodian Fisheries Administration and conservation organisations including Fauna & Flora International and the Song Saa Foundation have worked within the archipelago for over five years to develop the protected area, consulting with local stakeholders and communities and gathering baseline socioeconomic and biological data to support the designation of different zones inside the MFMA.

These zones will ensure that the MFMA supports both people and biodiversity by protecting important and vulnerable habitats (such as nursery and breeding sites), while also allowing for activities such as research, education, sustainable fishing and responsible tourism in other zones. This means that the protected area can sustain vital fisheries while protecting habitats, promoting ecotourism and reducing poverty.

The MFMA is situated approximately 20 km off the coast of Sihanoukville and is home to coral reef, seagrass and mangrove habitats, which support many charismatic species including sea turtles and seahorses. Three Community Fisheries located across the Prek Svay, Daem Thkov, Koh Touch, M'Pai Bai and Sok San villages are represented by locally-elected teams of fishermen who patrol and protect their fishing waters, keeping watch over the MFMA zones and representing their communityies at local and national meetings.

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Capacity building conference for conservation in Asia

Conservation organisations in Asia face a growing diversity of serious environmental issues. Long-term solutions to these problems will require actions by organisations, individuals and communities with the capacity to undertake a range of technical and process-based activities.

The third in a series of four international conferences on capacity building for conservation will be hosted by Pune University, India from 18 to 21 March 2017. The meeting is being organised by Ecological Research & Training Ltd. (UK), the Indian Herpetological Society and Pune University, and will provide a pan-Asian opportunity to review existing capacity initiatives, exchange ideas, develop and enhance networks, and formulate effective solutions to common capacity issues.

The conference has been designed to promote innovative and creative thinking around key issues and to draw on the experience and participation of conference attendees. Five thematic sessions will be led by Asian organisations and begin with invited talks, followed by facilitated workshops with specific tasks. The invited talks will act as demonstration projects to identify core issues, barriers, problems and potential solutions. This will be achieved through structured and facilitated group discussions. The thematic sessions will include:

- Developing and maintaining taxonomic skills in Asia
- Conservation science: building capacity to really use our species and habitat data for conservation action
- Learning from leaders: lessons in achieving organisational goals from five Asian conservation leaders
- Is it working: how can we evaluate the impact of our capacity building efforts?
- Developing a community of practice in Asia

One day of the meeting has also been set-aside to provide conference delegates with a wide range of free training events. Further information and registration forms can be found at the conference website (www.ert-conservation.co.uk/asia_capacity_intro.php).

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Short Communication

New records of Orchidaceae from Cambodia III

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Paper submitted 30 September 2016, revised manuscript accepted 27 October 2016.

In continuation of Schuiteman *et al.* (2015) and Schuiteman *et al.* (2016), we here report and illustrate nine orchid species not previously recorded from Cambodia. All but one were found in sterile condition in the field and could only be fully identified once the living specimens collected in November 2013 and May 2015 flowered in the glasshouses at the Royal Botanic Gardens, Kew (UK). The one exception is *Cleisostoma birmanicum*, which was in full flower when we encountered it. The following are new generic records for Cambodia: *Diploprora*, *Sarcoglyphis*, and *Stichorkis*.

In the interests of conservation we do not provide exact localities. Global distribution data follow Govaerts *et al.* (2016), unless indicated otherwise. Vouchers of all specimens mentioned are kept in the Kew Spirit Collection.

Species recorded

***Cleisostoma birmanicum* (Schltr.) Garay (Kew cult. 2015-1358; Figs 1 & 2)**

This monopodial epiphyte was found in flower on 15 May 2015, growing in a patch of scrub-like forest on the summit of Mt. Bokor at 1,000 m asl (above sea level). It was previously recorded from Myanmar, Thailand, China (Hainan), Laos (Schuiteman *et al.*, 2008) and Vietnam.

***Dendrobium heterocarpum* Wall. ex Lindl. (Kew cult. 2013-1685; Fig. 3)**

Most of the species of *Dendrobium* sect. *Dendrobium*, to which *D. heterocarpum* belongs, are highly sought after by collectors, both for the horticultural trade and for traditional Chinese medicine (Schuiteman *et al.*, 2008). This may explain why we only found a single specimen of this species in evergreen forest in the southern foothills of the Cardamom Mountains, lying on a forest trail, with its roots cleanly detached from whatever its support had been. It looked as if it had been accidentally dropped by a collector. This is a widespread species, ranging from Sri Lanka and India throughout tropical continental Asia to the Philippines and Indonesia, as far east as Sulawesi.

***Dendrobium oligophyllum* Simond ex Gagnep. (Kew cult. 2015-1258; Fig. 4)**

This small member of *Dendrobium* sect. *Distichophyllae* was found about 46 km north of Sen Monorom, Mondulkiri Province, growing as an epiphyte in dry, open forest at 315 m asl. It was previously recorded from Thailand, Laos, and Vietnam.

***Diploprora championii* (Lindl.) Hook.f. (Kew cult. 2013-1718; Fig. 5)**

This small monopodial orchid was found as an epiphyte in rather dry primary evergreen montane forest with little undergrowth at ca. 895 m asl. It is interesting to note that this species and *C. birmanicum* mentioned above both have a similar forked appendage at the lip apex, the

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Fig. 1 *Cleisostoma birmanicum* (Schltr.) Garay. In situ, Mt. Bokor.

Fig. 3 *Dendrobium heterocarpum* Wall. ex Lindl. Flower. Kew cult. 2013-1685.

Fig. 2 *Cleisostoma birmanicum* (Schltr.) Garay. Flowers.

Fig. 4 *Dendrobium oligophyllum* Simond ex Gagnep. Flowering plant. Kew cult. 2015-1258.

Fig. 5 *Diploprora championii* (Lindl.) Hook.f. Flowering plant. Kew cult. 2013-1718.

Fig. 7 *Phalaenopsis difformis* (Wall. ex Lindl.) Kocyan & Schuit. Flowers. Kew cult. 2015-1166.

Fig. 6 *Oberonia falcata* King & Pantl. Inflorescence. Kew cult. 2015-1311.

Fig. 8 *Sarcoglyphis thailandica* Seidenf. Flowers. Kew cult. 2015-1147.

Fig. 9 *Stichorkis gibbosa* (Finet) J.J.Wood. Plant habit. Kew cult. 2015-1312.

Fig. 10 *Stichorkis gibbosa* (Finet) J.J.Wood. Inflorescence. Kew cult. 2015-1312.

function of which (if any) is unknown. This widespread species ranges from Sri Lanka through tropical continental Asia, including Laos (Schuiteman *et al.*, 2008), to Taiwan.

***Oberonia falcata* King & Pantl. (Kew cult. 2015-1311; Fig. 6)**

With its somewhat anthropomorphic flowers this species resembles *O. anthropophora* Lindl. and *O. rufilabris* Lindl., both of which may occur in Cambodia, although only the latter has so far been found there. *Oberonia falcata* is easily distinguished by the elongate stems, as opposed to the stemless, fan-shaped habit of the two other species, and also by the very short floral bracts, which are (much) longer than the ovary in the other species. It was found as an epiphyte in evergreen montane forest at 940 m asl on Mt. Bokor, Kampot Province. This species was previously recorded from NE India, Nepal, Myanmar, China (Yunnan), Thailand, Laos (Schuiteman *et al.*, 2008), Vietnam, and North Sumatra.

Fig. 11 *Thrixspermum pauciflorum* (Hook.f.) Kuntze. Flowers. Kew cult. 2015-1120.

***Phalaenopsis difformis* (Wall. ex Lindl.) Kocyan & Schuit. (Kew cult. 2015-1166; Fig. 7)**

Until recently this taxon was better known as *Ornithochilus difformis* (Wall. ex Lindl.) Schltr., but DNA evidence has suggested its placement in *Phalaenopsis*. This is one of many orchid species of which the occurrence in Cambodia was entirely predictable. We encountered it as an epiphyte in semi-deciduous forest at ca. 595 m asl, ca. 8.5 km north of Sen Monorom, Mondulkiri Province, and probably also in more humid, evergreen forest remnants near a waterfall at 640 m asl, ca. 14 km southeast of Sen Monorom, but we have not seen the latter specimens in flower. This species, of which the flowers are striking close up but inconspicuous from a distance, was previously recorded from N & NE India, Nepal, Myanmar, southern China, Thailand, Laos, Vietnam, Peninsular Malaysia, Sumatra, and Borneo.

***Sarcoglyphis thailandica* Seidenf. (Kew cult. 2015-1147; Fig. 8)**

Along with *Thrixspermum pauciflorum*, this is the least common of the species reported in this paper. Until now this monopodial orchid was believed to be endemic to Thailand, but we found it at a considerable distance from the Thai border in eastern Cambodia, in the Seima Wildlife Sanctuary, Mondulkiri Province. There it occurred as an epiphyte in disturbed evergreen dipterocarp forest at 340 m asl.

***Stichorkis gibbosa* (Finet) J.J.Wood (Kew cult. 2015-1312; Figs 9 & 10)**

The last word has not been spoken on the complex taxonomy of subtribe Malaxidinae, which in Cambodia is represented by the genera *Crepidium*, *Liparis*, *Oberonia*, and now also by *Stichorkis*. The genus *Stichorkis* was usually considered to fall within the limits of the large genus *Liparis*, but molecular studies have shown that *Liparis* is polyphyletic (Cameron, 2005; Tang *et al.*, 2015). One clearly monophyletic group within *Liparis* s.l. includes the present species; all its members are characterized by having distichous, flattened floral bracts, with the flowers opening in succession over a long period of time (not unlike many species of *Thrixspermum*). *Stichorkis gibbosa* is the most widespread taxon in the genus, being recorded from Myanmar, Thailand, Laos, Peninsular Malaysia, many parts of Indonesia, the Solomon islands, Vanuatu, and New Caledonia. We found it as an epiphyte in evergreen montane forest on Mt. Bokor, Kampot Province, at 940 m asl.

***Thrixspermum pauciflorum* (Hook.f.) Kuntze (Kew cult. 2015-1120; Fig. 11).**

Thrixspermum simondii Gagnep., Bull. Mus. Natl. Hist. Nat., sér. 2, 22: 627 (1951), syn. nov. ?*Thrixspermum odoratum* X.Q.Song, Q.Q.Meng & Y.B.Luo, Ann. Bot. Fennici 46: 595 (2009).

Due to its short-lived flowers, the genus *Thrixspermum* is among the least well represented orchid genera in herbaria. The present species is among the lesser known members of the genus, having been found once in Peninsular Malaysia and once in Vietnam, according to Seidenfaden (1992). However, *T. simondii* from Vietnam, which was described from a painting by Simond, reproduced in Seidenfaden (1992), appears indistinguishable from *T. pauciflorum*. It is not clear to us on what grounds Seidenfaden chose to regard it as a synonym of *T. centipeda* Lour., albeit with a question mark. Judging from the illustrations in the protologue, *T. odoratum* from Hainan is very close to, if not conspecific with *T. pauciflorum*. We can here report *T. pauciflorum* from 15 km SE of Sen Monorom, Mondulkiri Province, where it occurred as an epiphyte in patches of secondary forest in anthropogenic grassland at 900 m asl.

Conclusions

Many new records of orchids are still to be expected from Cambodia, of which a large number can be predicted on the basis of known distribution ranges and ecology. Almost all the species here recorded, with the possible exceptions of *S. thailandica* and *T. pauciflorum*, are such predictable cases. The two last-mentioned species demonstrate, however, that there are still surprises in store, and that certainly not the entire orchid flora of Cambodia is as easily predictable as, say, the occurrence of *P. difformis* in the country.

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References

Cameron, K.M. (2005) Leave it to the leaves: a molecular phylogenetic study of Malaxideae (Epidendroideae, Orchidaceae). *American Journal of Botany*, **92**, 1025–1032.

Govaerts, R., Bernet, P., Kratochvil, K., Gerlach, G., Carr, G., Alrich, P., Pridgeon, A.M., Pfahl, J., Campacci, M.A., Holland Baptista, D., Tigges, H., Shaw, J., Cribb, P., George, A., Kreuz, K. & Wood, J.J. (2016) *World Checklist of Orchidaceae*. Facilitated by the Royal Botanic Gardens, Kew. Http://apps.kew.org/wcsp/ [Last accessed 11 April 2016].

Schuiteman, A., Bonnet, P., Svengsuksa, B. & Barthélémy, D. (2008) An annotated checklist of the Orchidaceae of Laos. *Nordic Journal of Botany*, **26**, 257–314.

Schuiteman, A., Ryan, C. & Nut M. (2015) New records of Orchidaceae from Cambodia I. *Cambodian Journal of Natural History*, **2015**, 131–138.

Schuiteman, A., Ryan, C., Nut M., Nay S. & Att, S. (2016) New records of Orchidaceae from Cambodia II. *Cambodian Journal of Natural History*, **2016**, 7–14.

Seidenfaden, G. (1992) The orchids of Indochina. *Opera Botanica*, **114**, 1–502.

Tang G.D., Zhang G.Q., Hong W.J., Liu Z.J., & Zhuang X.Y. (2015) Phylogenetic analysis of Malaxideae (Orchidaceae: Epidendroideae): two new species based on the combined nrDNA ITS and chloroplast matK sequence. *Guihaia*, **35**, 447–463.

Dacrydium elatum (Podocarpaceae) in the montane cloud forest of Bokor Mountain, Cambodia

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មូលន័យសង្ខេប

ឧទាហរណ៍ជាគំរូមួយនៃព្រៃតឿនៅតាមភ្នំនៃព្រៃត្រូពិច អាចត្រូវបានឃើញនៅតំបន់ខ្ពង់រាបនៃជួរភ្នំដំរីក្នុងឧទ្យានជាតិបូកគោ។ ជម្រាលចោទនៅទិសខាងត្បូងនៃជួរភ្នំ និង ជិតសមុទ្របង្កើតជាតំបន់មានលក្ខខ័ណ្ឌសើមខុសប្រក្រតី ដែលមានកម្ពស់ទឹកភ្លៀងលើសពី ៥០០០ ម.ម នៃកម្ពស់ទឹកភ្លៀងប្រចាំឆ្នាំ មានសណ្តានដាច់ៗ និងមានអាស៊ីតខ្ពស់។ លក្ខខ័ណ្ឌទាំងនេះបង្កើតឲ្យមានព្រៃតឿ និង ទីចុលព្រឹក្សដែលភាគច្រើនជាប្រភេទ *Dacrydium elatum* (Podocarpaceae)។ បម្រែបម្រួលទំហំដើមឈើត្រូវបានប្រទះឃើញកម្ពស់ចាប់ពី ៥-៧ ម. នៅតាមជម្រាលជិតកំពូលនិងបន្តរហូតតាមតំបន់បម្រែបម្រួល និង កម្ពស់ដល់ ១៥ ម. ក្នុងតំបន់ក្បែរទឹកធ្លាក់ពពកវិល។ ស្លឹកដែលមានសណ្តានដូចស្រកានៃដើមឈើពេញវ័យ និង សណ្តានទ្រវែងស្រួចចុងនៃកូនរុក្ខជាតិប្រភេទ *D. elatum* បង្ហាញពីទំនោរកទិសពន្លឺធ្វើរស្មីសំយោគ ហើយលក្ខណៈនេះក៏បង្ហាញពីការបន្សាំទៅនឹងលក្ខខ័ណ្ឌពពកច្រើននៃជម្រកនៅភ្នំបូកគោ។ ទម្រង់ទាំងពីរបានឈានដល់ ៥០% នៃអត្រាអតិបរមានៃការជ្រាបថាមពលពន្លឺកម្រិតទាបគឺត្រឹមតែ ២០០មីក្រូម៉ូល/ម៉ែត្រ/ វិនាទី។ អត្រាអតិបរមានៃការជ្រាបថាមពលពន្លឺឡើងខ្ពស់រហូតដល់ប្រហែល ៨០០ មីក្រូម៉ូល/ម៉ែត្រ/ វិនាទី នៅក្នុងទម្រង់ស្លឹកទាំងពីរ ប៉ុន្តែវាខ្ពស់ជាងនេះសម្រាប់ស្លឹកកូនរុក្ខជាតិតូចៗ។ អត្រាធ្វើរស្មីសំយោគខ្ពស់កើតមាននៅពេលប្រសិទ្ធភាពនៃការប្រើប្រាស់ទឹកថយចុះ។

Abstract

A classic example of a dwarf montane tropical forest can be seen in the plateau area of the Elephant Mountains in Bokor National Park. The steep south-facing slopes of the range and close proximity of the ocean produces unusually wet conditions with more than 5,000 mm of rainfall annually, and skeletal and highly leached acid soils. These conditions produce a dwarf forest and sclerophyllous shrubland dominated by *Dacrydium elatum* (Podocarpaceae). A distinct gradient in tree size is present, ranging from heights of only 5–7 m near the escarpment through a transition zone to heights of 15 m about 4 km inland near the Popokvil Falls. The scale-like foliage of mature trees and linear-lanceolate foliage of saplings of *D. elatum* display distinctive light response curves for photosynthesis, with both showing adaptations to the cloudy conditions of their habitat on Bokor Mountain. Both forms reached 50% of maximum rates of net assimilation at a low irradiance of only 200 µmol m^{-2} sec^{-1}. Maximum assimilation rates peaked at about 800 µmol m^{-2} sec^{-1} in both forms, but were higher in the sapling foliage. Higher rates of photosynthesis come at the expense of declining water use efficiency.

Key Words Bokor National Park, *Dacrydium*, Podocarpaceae, tropical cloud forest, photosynthetic rate.

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Introduction

Although tropical montane cloud forests throughout the world exhibit a characteristic structure of dwarfed stature and low productivity, there is no single environmental factor, with the exception of physically low cloud cover, that is shared by all of these forests (Bruijnzeel & Veneklaas, 1998). High winds, saturated soils, impeded root respiration, physiological drought, high soil leaching with low nutrient availability, limited rooting volume of shallow soils, reduced solar insolation, and high humidity with reduced transpiration rates have individually or in combination been suggested as causal agents in stunting (Grubb, 1971, 1977; Weaver *et al.,* 1973). It has also been suggested that the collective influence of these limiting factors may be seen in low rates of canopy photosynthesis (Bruijnzeel & Veneklaas, 1998).

The plateau areas of the Cardamom and Elephant Mountains in southern Cambodia provide classic examples of dwarf tropical montane forests. While lower elevations support a rich wet evergreen forest community of angiosperm trees, the shallow soils and waterlogged depressions on the summits of these mountains are dominated by local mosaics of low sclerophyllous evergreen forest no more than 12–16 m in height. These dwarf forests can occur at any elevation, but are most typical of depressions on the summits or windward ridges of hills at 900–1,400 m elevation on poorly drained sites in a matrix of taller wet evergreen forest (Dy Phon, 1970; Rollet, 1972; Ayervanov *et al.,* 2003). The dominant species in these waterlogged sites are commonly *Dacrydium elatum* (Roxb.) Wall. ex Hook. (Podocarpaceae) and *Tristaniopsis merguensis* (Griff.) P.G.Wilson & J.T.Waterh. (Myrtaceae). A mixture of other tree species may be present, commonly including the conifers *Podocarpus pilgeri* Foxw. and *Dacrycarpus imbricatus* (Blume) de Laub. (Podocarpaceae). Although differing in floristic composition, these dwarf evergreen forests share many ecological features with the better-known *kerangas* heath forests of Borneo, as well as in the presence of *Dacrydium elatum* as a dominant or co-dominant tree (Brünig, 1974).

Our research has been focused on the massif of the Elephant Mountains in Bokor (Preah Monivong) National Park which rises abruptly from a narrow coastal plain along the Gulf of Thailand in southern Cambodia to an elevation of more than 1,000 m asl (above sea level), forming a vertical escarpment at its southern face (Fig. 1). The combination of the steep south-facing slopes of the range and close proximity of the ocean produces unusually wet conditions on the upper plateau of this range where more than 5,000 mm of rain falls annually and the dry season is relatively short (Averyanov *et al.,* 2003). This heavy rainfall has acted on the quartz sandstone substrate of the plateau of the Elephant Mountains to produce skeletal and highly leached acid soils. As a result of these conditions, the plateau supports unusual communities of dwarf forest and sclerophyllous shrubland (Fig. 2) despite the high rainfall (Dy Phon, 1970). Within this matrix of dwarf forest and shrubland are small areas of permanent bog habitat where soils remain saturated throughout the year because of indurated soil layers (Rundel *et al.,* 2003).

There were two objectives to our study. The first was to assess patterns of canopy architecture in *Dacrydium elatum*, the dominant canopy tree on the Bokor Plateau, in a gradient of sites from near Popokvil Falls to the southern escarpment of Bokor Mountain 4 km to the southwest. This gradient followed declining forest height, shallower soil profiles, and inferred increases in rainfall, cloud cover, and strength of wind. Our second objective was to collect ecophysiological data on the relationship of photosynthesis to solar irradiance in the foliage of *D. elatum* to assess its adaptation to the reduced irradiance caused by frequent cloud cover on Bokor Mountain, and to compare its responses to that of other conifers, both within tropical cloud forests and outside these habitats.

Methods

Study species

Dacrydium elatum is a relatively widespread species of Podocarpaceae with a range of distribution that includes southern China, Myanmar, Cambodia, Thailand, Laos, Vietnam, Malaysia (Peninsular, Sabah, and Sarawak), western Sumatra, and the Philippines where it is commonly found in montane or hill evergreen forests at elevations of 700–2,000 m (Ridley, 1911; Smitinand, 1968; Nguyen & Vidal, 1996; Rundel, 2001; Farjon 2010). It is one of only seven conifer species known from Cambodia (Thomas *et al.,* 2007). Despite its characteristic montane habitat, *D. elatum* is tolerant of saturated soil and oligotrophic conditions and occurs in lowland kerangas forests in Malaysia and Indonesia (Mead, 1925; Kartawinata, 1980; Maloney & McCormac, 1996; Farjon, 2010). In the Cardamom and Elephant Mountains of southern Cambodia it occurs in low evergreen forest, frequently with *Dacrycarpus imbricatus* (Blume) de Laub. (Nguyen & Vidal, 1996).

Under favourable growing conditions, *Dacrydium elatum* forms a tree of moderate size with heights up to 35 m or more and diameters up to 120 cm. The trunk is typically straight with ascending branches that form a

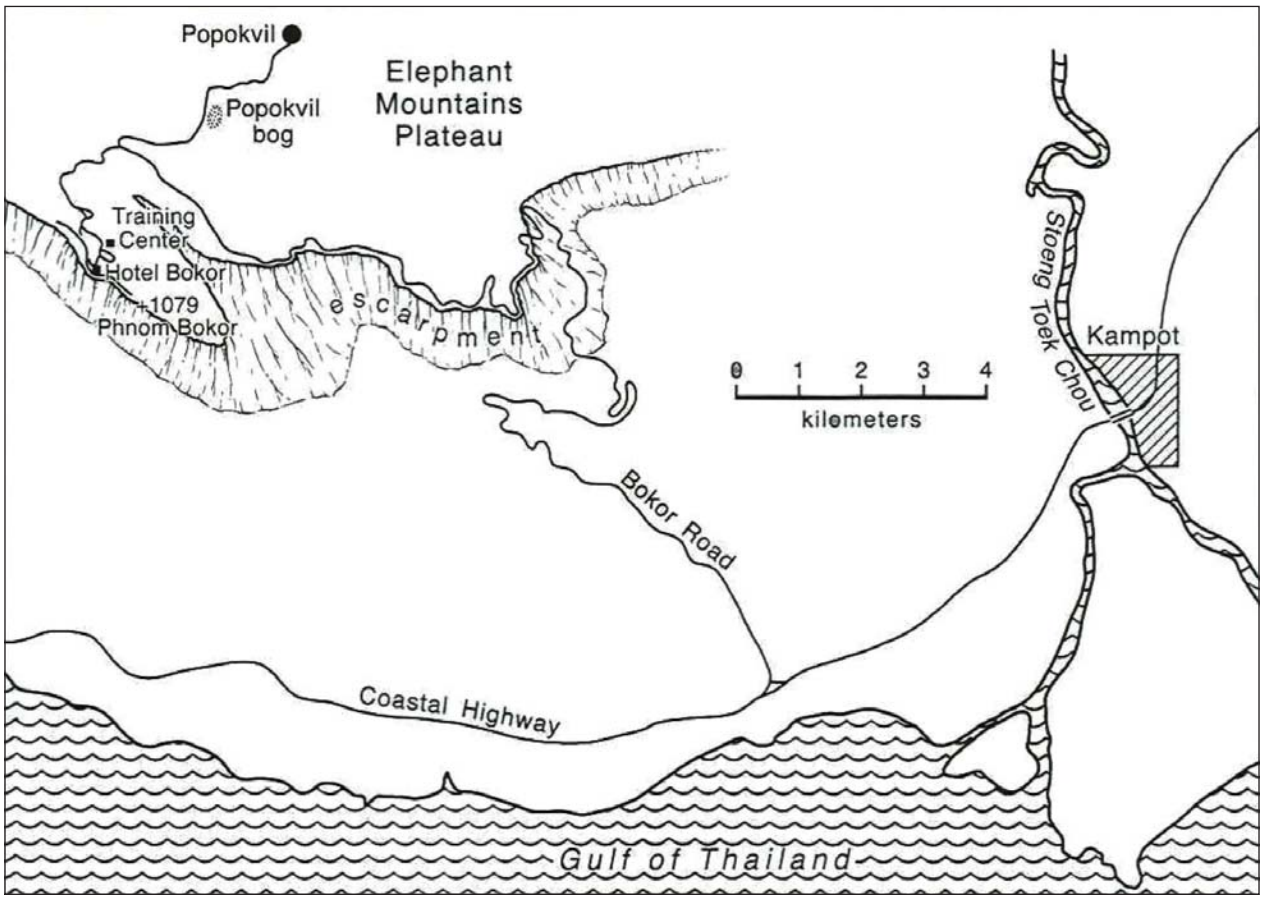

Fig. 1 Location of the study site in the Elephant Mountains Plateau of Bokor National Park. Phnom Bokor (Bokor Mountain) at 1,079 m, is the high point on the plateau. From Rundel *et al.* (2003).

domed canopy. The rough red bark of the trunk splits along vertical fissures and develops peeling strips. One of the unusual features of the species is the dimorphic form of foliage between saplings and mature trees. Juvenile foliage characteristic of young trees is comprised of spreading linear-lanceolate leaves up to 15–20 mm in length and keeled on four sides. In contrast, the foliage on mature trees consists of small and scale-like triangular leaves pressed to the branch shoots (Fig. 3).

Site description

Field studies were carried out from 3–13 March, 2001, on the plateau area of the Elephant Mountains in Bokor National Park, Kampot Province, Cambodia. Bokor National Park was established in 1997 and covers an area of 140,000 ha, much of it relatively undisturbed because of the steep topography (Rundel *et al.*, 2003).

The relatively high plateau of the southern Elephant Mountains slopes gently northward from its peak elevation of 1,062 m at the Bokor Palace Hotel at the edge of the escarpment (10°39′21.82″N, 104°01′35.20″E). Elevation drops 140 m over a 4 km distance from this high point to the site of Popokvil Falls (10°39′29.34″N, 104°03′04.38″E). This distance formed our study gradient and there is a significant change in the height of the dominant vegetation cover. Although environmental microclimates along our gradient were not quantified, the uplift of winds off the Gulf of Thailand produce the strongest wind speeds and highest amounts of rainfall near the south-facing escarpment, and these factors decrease in significance moving inland.

The sandstone substrate of the plateau of the Elephant Mountains weathers into an acidic coarse white sand. Soil profiles of the sphagnum bog, as described by Dy Phon (1970), consisted of upper sandy A horizons 90 cm thick with declining organic matter and increasing saturation with depth. The B horizon at 90–105 cm was an indurated layer of white sand, with yellowish sandstone parent material below this level. We measured the pH of

the soil solution as 4.6 in spot measurements made along the margin of the bog and in bog soils.

The impacted area around the sites of the old hotel and casino complex of Bokor were heavily disturbed and at the time of study (2001) were slowly undergoing a succession from weedy grasses and *Pteridium aquilinum* (L.) Kuhn to a scattered cover of low colonizing shrubs such as *Rhodamnia dumetorum* (DC.) Merr. & L.M. Perry (Myrtaceae), *Melastoma malabathricum* L. (Melastomataceae), *Ardisia crenata* Sims subsp. *crassinervosa* (E. Walker) C.M. Hu & J.E. Vidal, and *A. smaragdina* Pit. (Primulaceae). Most of this area has since been transformed with the development of new infrastructure and a hotel.

Rainfall is extremely high on the Bokor Plateau, averaging more than 5,000 mm annually. Records for Bokor (950 m elevation) at the southern end of the plateau show a mean annual rainfall of 5,309 mm (Tixier, 1979), while the Val d'Emeraude on the southeast margin of the plateau receives a mean of 5,384 mm (Dy Phon, 1970). The distribution of this rain is strongly seasonal, however, peaking in July and August and dropping to 50 mm or less per month in January and February at both stations. The Val d'Emeraude experiences rain almost every day from May through October, but on only 12 days on average in March (Dy Phon, 1970), the month of our sampling. Mornings during our field studies were typically semi-sunny with scattered clouds moving overhead, while heavier overcast conditions and brief periods of intense rain occurred almost every afternoon. Mean monthly temperatures are relatively constant throughout the year on Bokor Mountain, varying only from a low of 19.2 °C in July and August to a high of 21.5 °C in April (Dy Phon, 1970).

Sampling design

We sampled stem diameters at breast height and heights of 12–20 individual *D. elatum* at three positions along our study gradient: near Popokvil Falls, about 700–800 m north of the old Bokor Hotel, and roughly midway between these locations. Replicated gas exchange measurements were carried out over the course of the study at the intermediate site to evaluate the photosynthetic responses of mature foliage of both sapling and mature tree leaf morphologies. Net photosynthetic rate (A), stomatal conductance (g), transpiration (E), instantaneous (A/E) water-use efficiency (WUE), intrinsic WUE (A/g) and internal CO_2 concentration (C_i) were determined using a LI-6400 portable gas exchange system (LI-COR Inc., Lincoln, Nebraska, USA). The LI-6400 maintains steady-state conditions with respect to temperature, CO_2 and water vapour concentration within the assimila-

Fig. 2 Dwarf shrubland landscape of the Bokor Plateau, about 0.5 km north of the old Bokor Palace Hotel (© Leon Meerson).

Fig. 3 Dimorphic foliage of *Dacrydium elatum*: A) Mature tree (© biodivinf); B) Sapling (© Tony Rodd).

tion chamber. For the data curves we present, each data point represents the mean of 3–5 replicated measurements. Light response curves were also developed with replicated measurements for foliage of both saplings and mature individuals of *D. elatum*.

Light response curves were measured under constant leaf-to-air vapour pressure deficit (VPD) and temperature conditions. Field measurements were made by slowly increasing irradiance (PFD) from 0 to 1,400 μmol m^{-2} sec^{-1}. The ambient temperature inside the leaf chamber was kept at 20°C. This temperature was close to the maximum ambient daytime temperature when the measurements were made. The leaf-to-air vapour pressure deficit (VPD) was maintained at 0.5–0.9 kPa. The CO_2 concentration inside the leaf chamber was kept constant at 375 mmol mol^{-1} during the light response curves with CO_2 supplied from a pressurized 12 gram gas cylinder. Light was provided by an internal red/blue LED light source (LI6400-02B). The projected leaf area of foliage used in each measurement was determined after gas exchange measurement using millimetre graph paper.

Results

Small pockets of dwarf forest trees first appeared about 500 m north of the escarpment and more commonly about 1 km distant where we sampled dwarf populations of *D. elatum*. In these mosaic pockets, woody species with a clear tree-like growth form were found in fissures in the sandstone substrate where organic material had collected and soils had developed. In addition to *D. elatum*, common species of trees 3–5 m in height were *Neolitsea zeylanica* (Nees & T. Nees) Merr. (Lauraceae), *Vaccinium viscifolium* King & Gamble (Ericaceae), *Garcinia merguensis* Wight. (Clusiaceae), *Lithocarpus leiophyllus* A. Camus (Fagaceae), *P. pilgeri* (Podocarpaceae), *Dacrycarpus imbricatus* (Podocarpaceae), and *Syzygium formosum* (Wall.) Masam. (Myrtaceae). *Pandanus* cf. *capusii* Mart. (Pandancaceae) was also present as a common subcanopy species. Two semi-woody climbers occured among the shrubs and treelets: *Jasminum nobile* C.B. Clark (Oleaceae) and *Smilax davidiana* A.DC. (Smilacaceae). Open areas of rocky outcrop with shallow and seasonally inundated soils occurred as openings in the sclerophyll scrub, supporting stands of herbaceous species dominated by *Leptocarpus disjunctus* Mast. (Restionaceae) and the clump-forming sedge *Carex indica* L.

Mature individuals of *Dacrydium elatum* in these pockets of dwarf forest had diameters of up to 20–23 cm but reached only 5–7 m in height (Fig. 4). Moving inland along the gradient to a position roughly midway from the old Bokor Hotel to Popokvil Falls, there was a clear transition zone where soils were less shallow, with a more diverse set of associated species, and here mature individuals of *D. elatum* were 30–35 cm in diameter and 8–10 m in height. Finally, moving along the gradient approximately four km inland onto deeper soils in the area round Popokvil Falls, diameters of *D. elatum* reached 45–50 cm or more and heights up to 15 m. This area had a closed forest canopy with associated canopy trees that included taller individuals of those listed above as well as *Machilus odoratissimus* Nees (Lauraceae), *Syzygium lineatum* (DC.) Merr. & L.M. Perry (Myrtaceae), *Acronychia pedunculata* (L.) Miq. (Rutaceae), and *Calophyllum calababa* L. var. *cuneatum* (Symington ex M.R. Henderson & Wyatt-Smith) P.F. Stevens (Calophyllaceae). These are all trees that can reach 30–40 m in height under favorable growing conditions, although their height was comparable to *D. elatum* at the site.

Both mature and juvenile leaf morphologies of *D. elatum* have a light response curve for photosynthesis that shows adaptations to the cloudy conditions of their habitat on Bokor Mountain. Both forms reached 50% of maximum rates of net assimilation at an irradiance of only 200 μmol m^{-2} sec^{-1} (Fig. 5). Maximum assimilation rates peaked at about 800 μmol m^{-2} sec^{-1} in both forms but with very divergent maximum rates of net assimilation. Mature foliage reached light saturation at about 800 μmol m^{-2} sec^{-1} with a maximum assimilation rate of about 6 μmol m^{-2} sec^{-1}. While juvenile foliage morphology peaked at the same level of irradiance, it peaked at a much higher assimilation rate of about 10.5 μmol m^{-2} sec^{-1}.

Because transpiration rates increased faster than assimilation rates in both leaf morphologies as irradiance increased beyond about 400 μmol m^{-2} sec^{-1}, water use efficiency measured as the ratio of assimilation to transpiration peaked at this relatively low light level (Fig. 6). Higher rates of photosynthesis thus come at the expense of declining water use efficiency (Fig. 7).

Discussion

Only rarely are Podocarpaceae able to establish stand dominance in competition with angiosperm trees. Such a pattern is most common in azonal tropical montane sites with stressful conditions for plant growth, as in heath and swamp forests and in areas with skeletal oligotrophic soils. The dominance of *D. elatum*, with the associated *Dacrycarpus imbricatus* and *Podocarpus pilgeri*, on the Bokor Plateau fits a pattern seen widely in such habitats in Malesia and New Guinea (Enright & Jaffré, 2011). The causal factors for this dominance can be understood

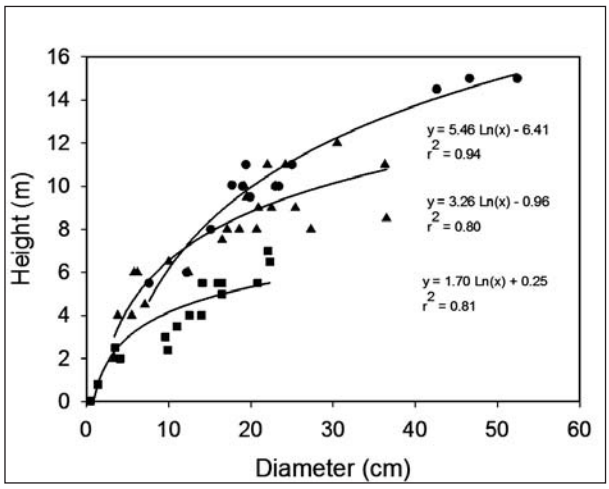

Fig. 4 Relationships of tree height to basal diameter in forest (circles), transition zone (triangles), and dwarf (squares) populations of *Dacrydium elatum* along a stress gradient across the Bokor Mountain Plateau of Bokor National Park, Cambodia. See text for details. Each symbol represents a measured individual.

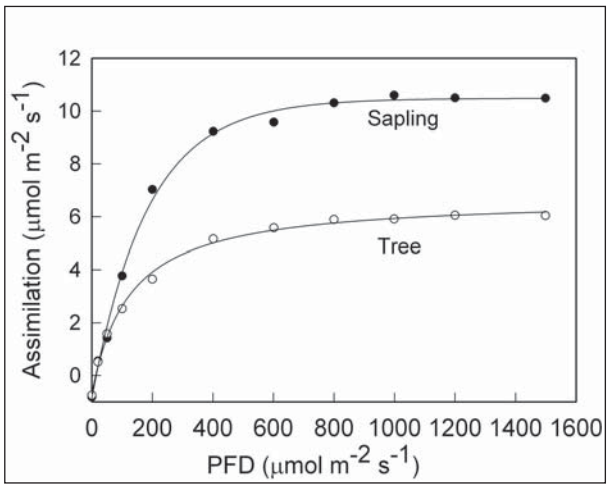

Fig. 5 Light response curve of mature tree and sapling foliage of *Dacrydium elatum* in Bokor National Park, Cambodia. These curves show replicated measurements on single co-occurring individuals located in the middle of the study gradient.

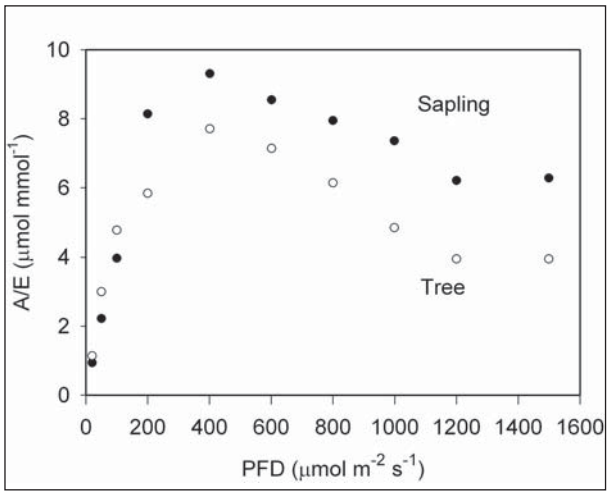

Fig. 6 Water use efficiency, measured as the ratio of assimilation (A) to transpiration (E), in relation to irradiance (PFD) in sapling and mature tree foliage of *Dacrydium elatum* in Bokor National Park, Cambodia. These curves show replicated measurements on single co-occurring individuals located in the middle of the study gradient.

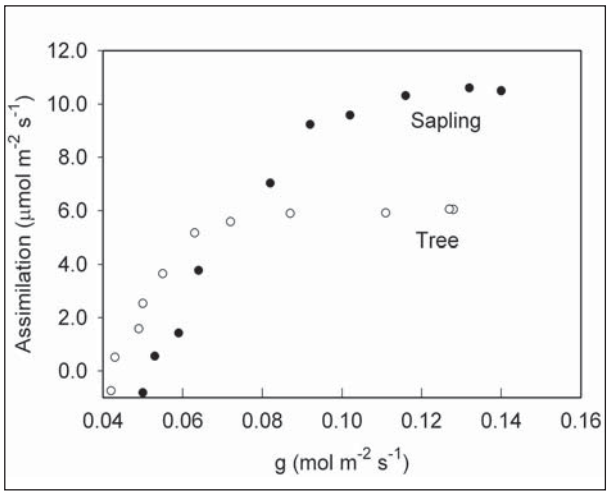

Fig. 7 Assimilation (A) to stomatal conductance (g) in sapling and mature tree foliage of *Dacrydium elatum* in Bokor National Park, Cambodia. These curves show replicated measurements on single co-occurring individuals located in the middle of the study gradient.

in traits broadly present in the Podocarpaceae. Although outcompeted on more productive sites, these conifers are able to persist in tropical forests using anatomical and morphological adaptations that increase the efficiency of light harvesting (Brodribb, 2011). Like many conifers, their slow growth also provides them a competitive advantage on oligotrophic soils. However, the Achilles heel of Podocarpaceae lies in the structure of their xylem systems and wood anatomy which makes them vulnerable to cavitation and thus drought stress (Brodribb,

2011), giving them poor hydraulic efficiency (Pitterman *et al.*, 2006). This morphology limits these taxa to areas of high water availability. The very high rainfall and shallow oligotrophic soils of the Bokor Plateau provide the conditions where these Podocarpaceae are able to maintain canopy dominance despite decreased stature.

The specific causal factors in the observed gradient in stature of *D. elatum* on Bokor Mountain are clearly complex, a pattern observed in other dwarf montane cloud forests (Bruijnzeel & Veneklaas, 1998). Increased dwarfing in growth form is associated with greater wind speeds, higher rainfall, shallower oligotrophic soils, and increased water logging. Photosynthetic measurements indicate that physiological limitations for carbon fixation may be less important than the abiotic stressors. The light response curve in foliage of *D. elatum* demonstrates clear adaptation to the low light levels present under the frequent cloud cover on Bokor Mountain. Moreover, the maximum rates of photosynthesis are high in comparison to published values for other Podocarpaceae (Meinzer *et al.*, 1984; Rundel *et al.*, 2001; Lusk *et al.*, 2003; Brodribb *et al.*, 2007). It is difficult to speculate about the possible significance of the higher rate of assimilation measured in juvenile foliage. The morphological differences in adult and juvenile foliage may have selective significance in promoting early growth and establishment of saplings in these oligotrophic conditions.

Globally, dwarf stands of conifers on oligotrophic soils are not restricted to the Podocarpaceae and tropical montane cloud forests. A classic example of these can be seen in the cool Mediterranean-climate of Mendocino County in northern California where highly leached and acidic beach terraces are locally present in an area known as the Pygmy Forest. Here, the endemic *Hesperocyparis pygmaea* (Lemmon) Bartel. (pygmy cypress), and *Pinus contorta* Loudon. subsp. *bolanderi* (Parl.) Critchf. (Bolander pine) often reach no more than 1–2 m in height after a century of growth (Westman, 1975).

The montane cloud forest of Bokor National Park is an important conservation resource deserving of additional study and protection. Much of this area, however, has been subject to recent development and clearing, putting many of the rare species and habitat at risk.

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References

Averyanov, L.V., Loc P.K., Nguyen T.H. & Harder D.K. (2003) Phytogeographic review of Vietnam and adjacent areas of Eastern Indochina. *Komarovia*, **3**, 1–83.

Brodribb, T.J. (2011) A functional analysis of podocarp ecology. *Smithsonian Contributions to Botany*, **95**, 165–173.

Brodribb, T.J., Feild, T.S. & Jordan, G.J. (2007) Leaf maximum photosynthetic rate and venation are linked by hydraulics. *Plant Physiology*, **144**, 1890–1898.

Brünig, E.F. (1976) *Ecological studies in kerangas forests of Sarawak and Brunei*. Sarawak Forest Department, Kuala Lumpur, Malaysia.

Bruijnzeel, L.A. & Veneklaas, E.J. (1998) Climatic conditions and tropical montane forest productivity: the fog has not lifted yet. *Ecology*, **79**, 3–9.

Dy Phon P. (1970) La vegetation du sud-ouest du Cambodge: Secteur Baie de Kompong Som, Chaine de l'Elephant et Plateau de Kirirom. *Annales de la Faculte, Academie de Phnom Penh*, **3**, 1–136.

Enright, N.J. & Jaffré, T. (2011) Ecology and distribution of Malesian podocarps. *Smithsonian Contributions to Botany*, **95**, 57–77.

Farjon, A. (2010) Podocarpaceae. In *Flora of Peninsular Malaysia, Series II: Seed Plants* (eds R. Kiew, Chung R.C.K., L.G. Saw, E. Soepadmo & Boyce, P.C.), pp. 171–203. Forest Research Institute, Kepong, Selangor, Malaysia.

Grubb, P.J. (1971) Interpretation of the "Massenerhebung" effect on tropical mountains. *Nature*, **229**, 44–45.

Grubb, P.J. (1977) Control of forest growth and distribution on wet tropical mountains with special reference to mineral nutrition. *Annual Review of Ecology and Systematics*, **8**, 83–107.

Kartawinata, K. (1980) A note on a kerangas (heath) forest at Sebulu, East Kalimantan. *Reinwardtia*, **9**, 429–447.

Lusk, C.H., Wright, I. & Reich, P.B. (2003) Photosynthetic differences contribute to competitive advantage of evergreen angiosperm trees over evergreen conifers in productive habitats. *New Phytologist*, **160**, 329–336.

Maloney, B.K. & McCormac, F.G. (1996) Palaeoenvironments of North Sumatra: a 30,000 year old pollen record from Pea Bullok. *Bulletin of the Indo-Pacific Prehistory Association*, **14**, 73–82.

Meinzer, F.C., Goldstein, G. & Jaimes, M. (1984) The effect of atmospheric humidity on stomatal control of gas exchange in two tropical coniferous species. *Canadian Journal of Botany*, **62**, 591–595.

Nguyen T.H. & Vidal, J.E. (1996) Gymnospermae. *Flore du Cambodge, du Laos et du Vietnam*, **28**, 3–161.

Pittermann, J., Sperry, J.S., Wheeler, J.K., Hacke, U.G. & Sikkema, E.H. (2006) Mechanical reinforcement of tracheids compro-

mises the hydraulic efficiency of conifer xylem. *Plant, Cell & Environment*, **29**, 1618–1628.

Rollet, B. (1972) La végétation du Cambodge. *Bois et Foréts des Tropiques*, **144**, 3–14; **145**, 34–30; **146**, 4–20.

Rundel, P.W. (2001) Forest habitats and flora in Lao P.D.R, Cambodia and Vietnam. In *Towards a Vision for Biodiversity Conservation in the Forests of the Lower Mekong Ecoregion. Technical Annex* (eds M.C. Baltzer, Nguyen T.D. & Shore, R.G.), pp. 11–19. WWF US and WWF Indochina, Washington, USA and Hanoi, Vietnam.

Rundel, P.W., Middleton, D.J., Patterson, M. & Monyrak M. (2003) Structure and ecological function in a tropical montane sphagnum bog of the Elephant Mountains, Bokor National Park, Cambodia. *Natural History Bulletin of the Siam Society*, **51**, 185–195.

Rundel, P.W., Patterson, M., Boonpragob, K. & Watthana, S. (2001) Photosynthetic capacity in Thai conifers. *Natural History Bulletin of the Siam Society*, **49**, 295–303.

Schmid, M. (1974) Végétation du Viet-Nam: le massif sud-annamitique et les régions limitrophes. *Mémoire ORSTOM*, **74**, 1–243.

Smitinand, T. (1968) *Vegetation of Khao Yai National Park*. Siam Society, Bangkok, Thailand.

Thomas, P., Sengdala, K., Lamxay, V. & Khou E. (2007) New records of conifers in Cambodia and Laos. *Edinburgh Journal of Botany*, **64**, 37–44.

Tixier, P. (1979) *Bryogéographie du Mont Bokor (Cambodge)*. J. Cramer, Vaduz, Liechtenstein.

Weaver, P.L., Medina, E., Pool, D., Dugger, K., Gonzales-Liboy, J. & Cuevas, E. (1986) Ecological observations in the dwarf cloud forest of the Luquillo Mountains in Puerto Rico. *Biotropica*, **18**, 79–85.

Westman, W.E. (1975) Edaphic climax pattern of the pygmy forest region of California. *Ecological Monographs*, **45**, 109–135.

Short Communication

Reproductive size thresholds of dipterocarps in Cambodian dry forests

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Tree size at the transition from juvenile (sterile) to adult (fertile) is an important species-specific character used to gain insight into the mechanisms governing forest structure and species coexistence. Various studies of this relationship in tropical forests have been attempted (Wright *et al.*, 2005). From a conservation perspective, such information also has practical applications. Seasonal tropical forest, representing 42% of tropical forests, is one of the most threatened ecosystems in the tropics (Murphy & Lugo, 1986). Currently, human population growth is causing deforestation pressure in Cambodia. For aseasonal dipterocarp forests, it has been proposed that management programmes should ensure genetic diversity and pollination efficacy (Tani *et al.*, 2009, 2012). To develop guidelines for sustainable forest use in Cambodia, basic information on forest stands and their regeneration is necessary. To this end, we determined the flowering size for components of a Cambodian dry dipterocarp forest.

The study was conducted in two permanent sample plots established in typical dry dipterocarp forests in Cambodia (Fig. 1). The first was a 4 ha (200 m × 200 m) study plot centered on a flux tower in Kratie Province (KRC, 12.9°N, 106.2°E; elevation: 74–85 m). The KRC plot has three dominant deciduous dipterocarp species: *Dipterocarpus tuberculatus* Roxb. (ca. 31% of stand basal area and 20% of stand tree number), *Shorea siamensis* Miq. (19% and 40%, respectively), and *S. obtusa* Wall. ex Blume (18% and 9%, respectively), which are associated with *Terminalia alata* Heyne ex Roth (13% and 14%, respectively). Tree density and basal area for stems with a diameter at breast height (DBH, 1.3 m above ground level) of ≥ 5 cm were 557 stem ha^{-1} and 13.6 m^2 ha^{-1}, respectively. Tertiary and quaternary sedimentary rocks underlie much of the forest (Toriyama *et al.*, 2010), and the soil type is plinthic hydromorphic. The KRC plot, in part, experiences an annual fire regime based on a plentiful supply of grasses as fuel and usually involves man-made fires created while hunting for wildlife.

The second plot was a 0.24 ha (30 m × 80 m) study plot located in Kampong Thom Province (KPT, 12.8°N, 105.5°E; elevation: 70 m). The KPT plot has one dominant dipterocarp species, *Dipterocarpus obtusifolius* Teijsm. ex Miq. (ca. 50% of stand basal area and 60% of stand tree number), which is associated with *Gluta laccifera* (Pierre) Ding Hou (35% and 6%, respectively) (Hiramatsu *et al.*, 2007). The forest does not show distinct deciduousness, but irregular, incomplete leaf shedding of its components (Ito *et al.*, 2007). Nevertheless, the forest is placed in the deciduous forest category in the Cambodian forest type classification (Forestry Administration, 2011). Tree density and basal area for stems with DBH ≥ 5 cm were

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408 stem ha^{-1} and 12.3 m^2 ha^{-1}, respectively. The site was located on extensive quaternary sedimentary rock and its soils are classified as acrisols, but with albic and arenic features that suggest a closer relationship with arenosols (Toriyama *et al.,* 2007).

The climate of the research areas is seasonal tropical, and the months from November through April are dry. Mean annual temperature is 27 °C. Annual rainfall (mean ± SD) is 1,643 ± 272 mm in KRC and 1,542 ± 248 mm in KPT (2000–2010: NIS, 2012).

We investigated the reproductive size thresholds of the four dipterocarp species mentioned above. We recorded the presence/absence of reproductive organs on trees within the KRC study plot in February 2009 (n = 68), 2010 (n = 68), 2011 (n = 1,186), 2012 (n = 953), and January–February 2014 (n = 1550, all trees). The same was done for all living trees within the KPT study plot in May 2003 and 2005, and in December 2005 and 2009. For all four dipterocarp species, flowers and flower buds were found in the dry season (December–February), while fruits were found in the subsequent early wet season (May). During our censuses, we measured the DBH of stems to the nearest 1 mm for all standing woody stems with DBH ≥ 5 cm. Tree size with and without reproduction was defined as DBH at the first recorded presence of reproductive organs and the last recorded absence of reproductive organs, respectively. We then determined the minimum tree size for reproduction in *D. obtusifolius*, *D. tuberculatus*, *S. obtusa*, and *S. siamensis* using nominal logistic regression models.

Sist *et al.* (2003) recommended a procedure for setting diameter-based cutting limits for trees according to their diameter at the onset of reproduction. All of the dipterocarps we studied are included in official guidelines which indicate their diameter-based cutting limits (0.50 m DBH for *D. tuberculatus*, 0.45 m DBH for the other species: MAFF, 2005). We found the mean diameters of reproductive trees were lower than these diameter limit criteria (Table 1). A reproductive tree population could therefore persist despite selective logging using these criteria (Fig. 2). Tree size significantly predicted the presence/absence of reproduction for all of our study species ($p<0.0001$). Nominal logistic regression models also indicated that >90% of individual trees start reproduction at smaller tree sizes than the diameter limit criteria (Fig. 3). These data suggest that the MAFF (2005) guidelines are sustainable in terms of diameter cutting limits for all of the dry dipterocarp species we studied.

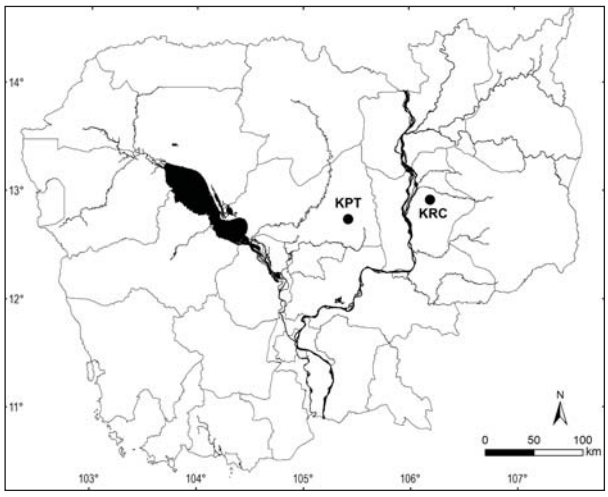

Fig. 1 Location of sample plots in Cambodia. KPT: Kampong Thom Province; KRC: Kratie Province.

Table 1 Minimum tree size for reproduction and reproductive tree density of dipterocarp species in Cambodian dry forests.

	D. obtusifolius	*D. tuberculatus*	*S. obtusa*	*S. siamensis*
Density (all trees) [1]	254	112	50	229
Density (reproductive trees) [1]	83	85	32	34
Tree DBH (all trees) [2]	15.5 ± 8.6 (46.4)	20.1 ± 8.7 (52.5)	23.6 ± 10.0 (55.8)	11.0 ± 5.3 (46.5)
Tree DBH (reproductive trees) [3]	22.8 ± 9.6 (12.0)	23.0 ± 7.4 (10.8)	27.4 ± 8.5 (9.8)	18.4 ± 6.8 (5.6)
DBH at 50% of tree reproduction [4]	18.8 (16.2–23.9)	12.3 (11.1–13.3)	17.9 (15.2–20.1)	18.1 (17.3–19.1)
DBH at 90% of tree reproduction [4]	27.1 (22.7–42.5)	20.0 (18.6–21.8)	31.5 (28.2–37.3)	24.3 (22.9–26.3)

[1] Stem ha^{-1}

[2] Mean ± SD (max.) [cm]

[3] Mean ± SD (min.) [cm]

[4] Estimated (95% CI) [cm]

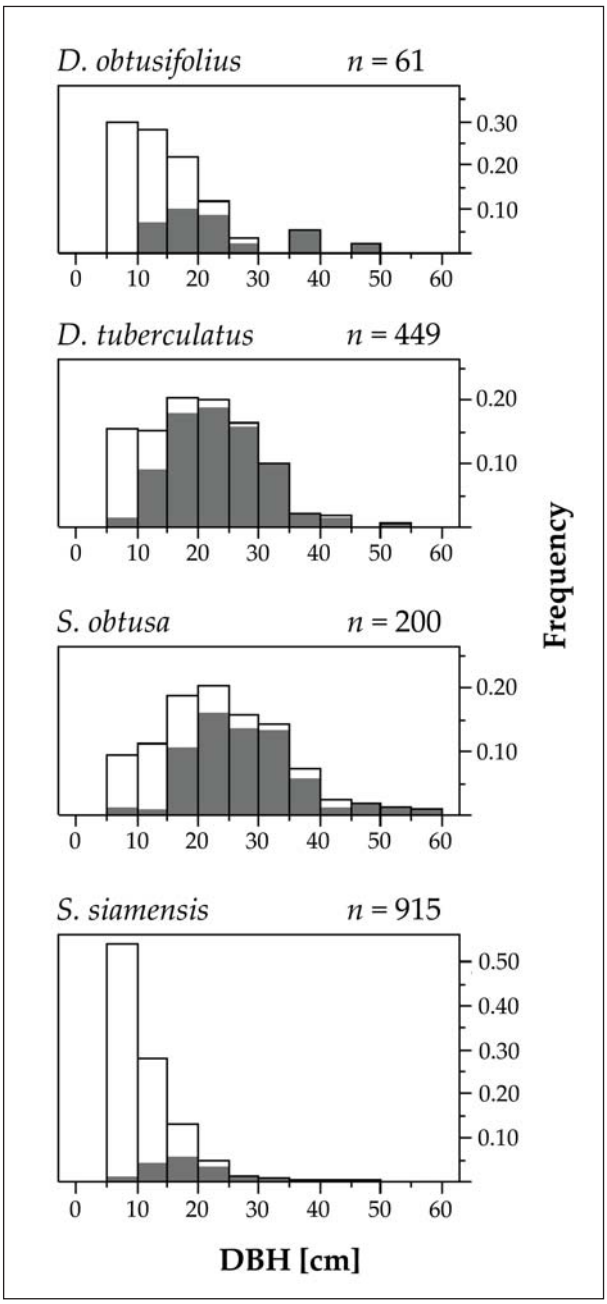

Fig. 2 Size (diameter at breast height, DBH) distribution of dipterocarp species in the study plots. Gray and white areas indicate trees with and without reproductive organs, respectively. Tree size with and without reproduction was defined as DBH at the first recorded presence of reproductive organs and the last recorded absence of reproductive organs, respectively.

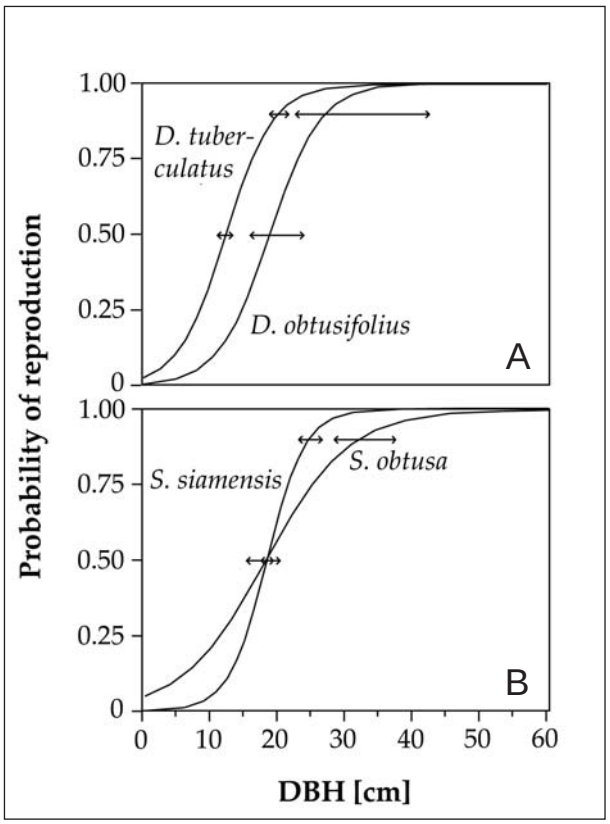

Fig. 3 Probability of reproduction based on the DBH estimated using nominal logistic regression for four dipterocarp species in Cambodian dry forests: A) *Dipterocarpus* spp.; B) *Shorea* spp. Horizontal arrows indicate the estimated 95% confidence interval of DBH at 50% and 90% probability of reproduction.

Reproductive target tree densities have been proposed as an acceptable vulnerability index value (>5 reproductive trees ha^{-1}) for Bolivian seasonally dry forests (Pinard *et al.*, 1999). The reproductive tree densities recorded in our study plots far exceeded this value (32–85 stems ha^{-1}, Table 1). However, total basal areas in the Bolivian forests were three times higher than the values in the dry dipterocarp forests we studied. A basal area mismatch of this magnitude indicates that the criteria for vulnerability index scoring should be independently verified in Cambodian forests.

The distribution of diameters differed among the species in our study (Fig. 2). Only *S. siamensis* showed a negative exponential distribution, indicating continual recruitment of juvenile trees, whereas *D. tuberculatus* and *S. obtusa* had unimodal distributions with peaks in the 15–25 cm DBH class. These data suggest low recruitment rates in *D. tuberculatus* and *S. obtusa*. This was obviously not due to a lack of flowering trees. Micro-sites suitable for the establishment of dipterocarp seedlings may be limited by topography or light conditions (Yagihashi *et*

al., 2010). In addition, fire in the dry season and grass shading in the wet season may inhibit seedlings in the KRC plot. In turn, the relatively higher recruitment of *S. siamensis* may be due to its frequent occurence in rocky soils (Rollet, 1972) as the lower grass biomass of these areas would weaken the impacts of fire and shading. For sustainable management, reproductive target tree densities should remain at high levels until the exact reasons for these differences in recruitment are known.

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References

Forestry Administration (2011) *Cambodia Forest Cover 2010*. Forestry Administration, Ministry of Agriculture, Forestry and Fisheries, Phnom Penh, Cambodia.

Hiramatsu R., Kanzaki M., Toriyama J., Kaneko T., Okuda Y., Ohta S., Khorn S., Pith P., Lim S., Pol S., Ito E. & Araki M. (2007) Open woodland patch and the isolated stand of *Melaleuca cajuputi* in an evergreen forest of Kampong Thom, Cambodia: a transect study along a micro-topography gradient. In *Forest Environments in the Mekong River Basin* (eds H. Sawada, M. Araki, N.A. Chappell, J.V. LaFrankie & Shimizu, A.), pp. 216–224. Springer, Tokyo, Japan.

Ito E., Khorn S., Lim S., Pol S., Tith B., Pith P., Tani A., Kanzaki M., Ohta S., Kaneko T., Okuda Y. & Araki M. (2007) Comparison of the leaf area index (LAI) of two types of dipterocarp forest on the west bank of the Mekong River, Cambodia. In *Forest Environments in the Mekong River Basin* (eds H. Sawada, M. Araki, N.A. Chappell, J.V. LaFrankie & Shimizu, A.), pp. 208–215. Springer, Tokyo, Japan.

MAFF (2005) Prakas on forbidding harvest of timber and non-timber forest products #89. Ministry of Agriculture, Forestry and Fisheries, Phnom Penh, Cambodia [in Khmer].

Murphy, P.G. & Lugo, A.E. (1986) Ecology of tropical dry forest. *Annual Review of Ecology and Systematics*, **17**, 67–88.

NIS (2012) *Statistical Yearbook of Cambodia 2011*. National Institute of Statistics, Ministry of Planning, Phnom Penh, Cambodia.

Pinard, M.A., Putz, F.E., Rumíz, D., Guzmán, R. & Jardim, A. (1999) Ecological characterization of tree species for guiding forest management decisions in seasonally dry forests in Lomerío, Bolivia. *Forest Ecology and Management*, **113**, 201–213.

Rollet, B. (1972) La végétation du Cambodge. *Bois et Forets des Tropiques*, **144**, 3–15; **145**, 24–38; **146**, 4–20.

Sist, P., Fimbel, R., Sheil, D., Nasi, R. & Chevallier, M.H. (2003) Towards sustainable management of mixed dipterocarp forests of South-east Asia: moving beyond minimum diameter cutting limits. *Environmental Conservation*, **30**, 364–374.

Tani N., Tsumura Y., Kado T., Taguchi Y., Lee S.L., Muhammad, N., Ng K.K.S., Numata S., Nishimura S. & Konuma A. (2009) Paternity analysis-based inference of pollen dispersal patterns, male fecundity variation, and influence of flowering tree density and general flowering magnitude in two dipterocarp species. *Annals of Botany*, **104**, 1421–1434.

Tani N., Tsumura Y., Fukasawa K., Kado T., Taguchi Y., Lee S.L., Lee C.T., Muhammad, N., Niiyama K., Otani T., Yagihashi T., Ripin, A. & Kassim, A.R. (2012) Male fecundity and pollen dispersal in hill dipterocarps: significance of mass synchronized flowering and implications for conservation. *Journal of Ecology*, **100**, 405–415.

Toriyama J., Ohta S., Araki M., Ito E., Kanzaki M., Khorn S., Pith P., Lim S. & Pol S. (2007) Acrisols and adjacent soils under four different forest types in central Cambodia. *Pedologist*, **51**, 35–49.

Toriyama J., Ohta S., Araki M., Kosugi K., Nobuhiro T., Kabeya N., Shimizu A., Tamai K., Kanzaki M. & Chann S. (2011) Soil pore characteristics of evergreen and deciduous forests of the tropical monsoon region in Cambodia. *Hydrological Processes*, **25**, 714–726.

Wright, S.J., Jaramillo, M.A., Pavon, J., Condit, R., Hubbell, S.P. & Foster, R.B. (2005) Reproductive size thresholds in tropical trees: variation among individuals, species and forests. *Journal of Tropical Ecology*, **21**, 307–315.

Yagihashi T., Otani T., Tani N., Nakaya T., Abd Rahman, K., Matsui T. & Tanouchi H. (2010) Habitats suitable for the establishment of *Shorea curtisii* seedlings in a hill forest in Peninsular Malaysia. *Journal of Tropical Ecology*, **26**, 551–554.

The hairy-nosed otter *Lutra sumatrana* in Cambodia: distribution and notes on ecology and conservation

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មូលន័យសង្ខេប

ភេរោមច្រមុះ (*Lutra sumatrana*) មានវត្តមានតែនៅក្នុងតំបន់អាស៊ីអាគ្នេយ៍តែប៉ុណ្ណោះ តែកំណត់ត្រាមានតិចតួច និង ចំណេះដឹងពីប្រភេទនៅមានកម្រិត។ ការសិក្សានេះត្រូវបានធ្វើឡើងក្នុងជម្រកតំបន់ទំនាបដីសើមជាច្រើនទូទាំងប្រទេសកម្ពុជា ពីឆ្នាំ២០០៦ ដល់ ២០១៣។ វិធីសាស្ត្រនៃការសិក្សា គឺសំភាសន៍ជាមួយនឹងសហគមន៍មូលដ្ឋាន ការអង្កេតដោយផ្ទាល់ មើលដាន ស្លាកស្នាម និង ការប្រើម៉ាស៊ីនថតស្វ័យប្រវត្តិដើម្បីថតផ្តិតរូបផ្ទាល់តែម្តង។ ភេរោមច្រមុះត្រូវបានគេប្រទះឃើញរស់នៅ៤កន្លែងក្នុងប្រទេសកម្ពុជាគឺ តំបន់ដីសើមបឹងទន្លេសាប តំបន់ជួរភ្នំក្រវាញ តំបន់ឆ្នេរខេត្តកោះកុង និង តំបន់វាលល្បាប់ដីសណ្តទន្លេបាសាក់។ កំណត់ត្រារបស់វា រួមមានភេរស់ចំនួន៨ ស្បែកចំនួន១៨ និង រូបថតដោយម៉ាស៊ីនថតស្វ័យប្រវត្តិចំនួន៧១ពីតំបន់សិក្សាចំនួន២៦។ ប្រភេទនេះត្រូវបានរកឃើញរស់នៅក្នុងទីជម្រកប្លែកៗគ្នាដូចជា៖ ព្រៃលិចទឹកទំនាបបឹងទន្លេសាប ទន្លេបាសាក់ ព្រៃកោងកាង ព្រៃស្មាច់ តំបន់ទំនាបវាលភក់ និង ស្ទឹងតាមតំបន់ភ្នំជាដើម។ យោងតាមការសិក្សានេះ រដូវកាលបន្តពូជរបស់វាគឺ ចន្លោះខែវិច្ឆិកាដល់ខែមិនា និង កើតកូនចន្លោះខែមីនាដល់មេសា។ ភេរោមច្រមុះច្រើនមានសកម្មភាពនៅពេលព្រលប់ និង ពេលយប់ ត្រីជាអាហារសំខាន់ និង អាហារបន្ទាប់បន្សំមាន ពស់ទឹក ក្តាម និង សត្វតូចៗផ្សេងទៀតដែលវាអាចចាប់ស៊ីបាន។ យើងសូមផ្តល់អនុសាសន៍អោយមានការសិក្សាបន្ថែមនៅតាមដងទន្លេមេគង្គ រវាងបឹងទន្លេសាប និង តំបន់តាមព្រំដែនវៀតណាម ក៏ដូចជាតាមតំបន់ឆ្នេរនៃឧទ្យានជាតិរាម ដើម្បីយល់ដឹងកាន់តែប្រសើរឡើងពីរបៀបភេរោមច្រមុះទូទាំងប្រទេសកម្ពុជា។

Abstract

The hairy-nosed otter *Lutra sumatrana* is endemic to Southeast Asia, however, records are few, and knowledge of the species is limited. This study was carried out in a range of wetland habitats throughout Cambodia between 2006 and 2013. Field methods included interviews with local communities, direct observations, and track and sign surveys combined with camera trapping. Hairy-nosed otters were confirmed from four regions in Cambodia: Tonle Sap Lake, Cardamom Mountains, Bassac Marsh and coastal areas in Koh Kong province. Records comprised eight live captive individuals, 18 skins, and 71 camera trap photographs from 26 trap locations. The species was recorded from several different habitats including flooded forest, mangrove and *Melaleuca* forest, marsh land and forest streams. Based on our records, we suggest the hairy-nosed otter in Cambodia may breed between November and March and give birth between April and June. We found the species was most active during dusk and at night, and although its diet mainly consists of fish, this is supplemented in Tonle Sap Lake with water snakes, crabs, and other small prey when the oppor-

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tunity arises. We recommend further surveys along the Mekong River between the Tonle Sap Lake and the Vietnamese border and at coastal sites such as Ream National Park to improve understanding of the distribution of the species in Cambodia.

Keywords

Cambodia, conservation, distribution, ecology, hairy-nosed otter, *Lutra sumatrana*, Tonle Sap Lake.

Introduction

The hairy-nosed otter *Lutra sumatrana* is endemic to Southeast Asia, with a historic range throughout the region (Aadrean *et al.,* 2016). Little is known about the species and until 2008, it was mostly classified as insufficiently known or data deficient by the IUCN/SSC Otter Specialist Group (Hussein *et al.,* 2008). It was also believed by some to be extinct after several years of no field records in the 1990s (Wright *et al.,* 2008). The discovery of hairy-nosed otters in a peat swamp forest in Thailand in 1999 by Kanchanasaka (2000), followed by confirmed records from Vietnam, Peninsular Malaysia and Indonesia (Hussein *et al.,* 2008) indicates that the species still occurs in these countries, although probably at low densities at few and little surveyed sites. Poole (2003) provided the first confirmed record of hairy-nosed otters in Cambodia through records of captive animals in floating houses on the Tonle Sap Lake.

As information has slowly increased on the hairy-nosed otter, the species is now listed as Endangered A2cde on the IUCN Red List (Aadrean *et al.,* 2015) due to a suspected population decline of at least 50% over the last three generations, extensive habitat destruction and conversion throughout its range, coupled with poaching for its skin and persecution as a pest (Yoxon, 2007). However, confirmed records are still few and far between, and knowledge of the species remains limited, making identification and prioritization of appropriate conservation measures difficult. Apart from a single individual held at the Phnom Tamao Zoological Garden and Rescue Center in Phnom Penh, Cambodia, no other captive individuals or breeding programs currently exist to the authors knowledge.

In this paper we document the presence and distribution of hairy-nosed otter in Cambodia and provide information on its ecology, which can inform efficient protection of the species and its habitats.

Methods

We carried out surveys in a range of wetland habitats throughout Cambodia between 2006 and 2013. These included Virachey National Park in northeastern Cambodia, along the Mekong River between the Stung Treng and Kratie provinces, the eastern plains of Cambodia, Tonle Sap Lake, Bassac Marsh, Cardamom Mountains, Ream National Park and coastal areas in Koh Kong Province (Fig. 1, Table 1). Survey areas were chosen based on the habitat requirements of otters, unconfirmed reports of their occurrence and relative ease of access.

Survey sites

Virachey National Park covers an area of 3,325 km² in the Ratanakiri and Stung Treng provinces of northeastern Cambodia and comprises lowland, hill and montane evergreen forest, as well as upland savannah, bamboo and patches of mixed deciduous forest (Hon *et al.,* 2010). Surveys were conducted along Tabok and Ka shep streams in evergreen and bamboo forest.

Survey sites along the Mekong River in the Kratie and Stung Treng provinces were located near the villages of Sambour, O'krieng, O'yeay, Achen and Kompong Chrey, at the islands of Koh Dombong and Kbal O'chom and at sites in Prey Lang Wildlife Sanctuary. The Mekong River has a lot of deep pools, as well as numerous small islands and sandbanks during the dry season, which are important habitats for wildlife (Poulsen *et al.,* 2002). Prey Lang Wildlife Sanctuary is located in the Kratie, Stung Treng and Preah Vihear provinces and mainly comprises lowland evergreen and deciduous forest. Survey sites within the wildlife sanctuary included the O'krack, Ponror, O'long and Kbal Damrey streams, which are connected to the Mekong River (Olsson *et al.,* 2007).

Several sites were surveyed within Keo Siema Wildlife Sanctuary in Mondulkiri province and Sre Pok Wildlife Sanctuary in Ratanakiri Province. In Keo Siema, we surveyed along the Opam, Khlong Khnong, and Pour streams, which are surrounded by evergreen and bamboo forests (Keo & Evans, 2013). Surveys in Sre Pok Wildlife Sanctuary focused on the Sre Pok River, a major tributary of the Mekong River, which is surrounded by dense lowland evergreen forest (Constable, 2015).

The Tonle Sap Lake is the largest wetland in Southeast Asia, with a unique flood-pulse system, high biodiversity, and very productive fisheries (Arias *et al.,* 2013). Located in central Cambodia, the dominant habitat of the

floodplain surrounding the lake is generally described as 'seasonally flooded forest'. This is divided into several vegetation types, and large areas are inundated by up to nine meters of water during the wet season between July and November. Gallery forests with trees between 7 and 15 m tall occur on the inner edge of the lake near open water, rivers, streams, and ponds where the ground rarely dries up. Lower tree cover and scrubland occurs on a larger proportion of the floodplain, with vegetation reaching heights of up to 4 m. Stationary and floating aquatic vegetation and grasslands are also common. These can reach a height of up to 3 m, and floating islands of vegetation occur along the edge of the lake and in canals (McDonald *et al.,* 1997).

The Bassac Marsh is located between the Bassac and Mekong Rivers in Kandal Province, 40 km south of Phnom Penh. It consists of swamp forest and wetlands similar to Tonle Sap, with scattered trees and scrubs such as *Barringtonia acutangula* and most of the associated emergent plants comprising *Sesbania rixburghii*, *Eiahormia crassipes* and *Utrcularia aurea* (UNEP, 2008). The marsh is inundated by up to 3 m of water during the wet season between July and November, and forms a wetland surrounding a narrow body of open water during the dry season. Due to its proximity to Phnom Penh and demand for land for rice cultivation, the site faces intense human pressure from agriculture and other development, such that the wetland is being converted to agriculture, landfills and human habituation (Heng, 2010).

The Cardamom Mountains span southwest Cambodia and neighouring areas of Thailand. The mountains are heavily forested with hill and lowland evergreen forest and contain many rivers and streams which flow southwards into the sea and northwards into Tonle Sap Lake (Campbell *et al.,* 2006). On the northern side of the mountains, the Takong stream flows into the Pursat River and subsequently into Tonle Sap Lake. The stream is rich in fish and surrounded by evergreen forest. Little water is present in the stream during the dry season, especially in April, except in deep pools. A large flooded grassland is located next to the stream, which provides suitable habitat for otters.

The coastal zone of southwest Cambodia is dominated by rivers draining the Cardamom Mountains, estuaries, mangrove and *Melaleuca* forest, with evergreen and bamboo forests occuring further upstream. Peam Krasop Wildlife Sanctuary is located in this area and is dominated by mangrove and *Melaleuca* forests (UNEP, 2008). These are intermixed with agriculture areas and grasslands. The rivers are rich in marine and freshwater fish and provide good habitat for otters. Sand-dredging in the rivers, hunting and land conversion are major threats to otters and other wildlife at the site (Dong *et al.,* 2010), and interviews indicate that local otter populations are in decline. Ream National Park, located in the coastal area of Sihanoukville Province, comprises similar habitats (Heng, 2010).

Sampling methods

Survey methods included semi-structured interviews of fishermen, hunters, rangers, and village chiefs whom often have good knowledge of local wildlife. Reference photographs of the otter species that occur in Cambodia were used during the interviews to aid species identification, although confirmed records of otter presence were not based on interview data alone. Interview results guided site selection for track and sign surveys and camera trapping.

As Hussain & Choudhury (1997) found otter signs were located within 12.5 m of water bodies, track and sign surveys were conducted within 20 m of water edges along rivers, streams and dry season ponds. Signs sought for included spraints, food remains, footprints, dens, and resting sites. The wetlands of Tonle Sap and Bassac Marsh are difficult to navigate through due to dense vegetation, which in some cases diverted survey effort. During the rainy season, boats were used to move around these areas. Although tracks of hairy-nosed otter and Eurasian otter *Lutra lutra* are very similar and difficult to distinguish (Kanchanasaka, 2001), the team learned to recognise spraints produced by different otter species from the IUCN Otter Specialist Group Chair Nicole Duplaix and so could confidently identify those produced by hairy-nosed otters. Despite this, records of otters were not regarded as confirmed unless substantiated by a camera trap photograph, skin or direct observation.

Camera traps were set at a total of 228 locations across the areas surveyed (Table 1). Different camera traps were used during the survey (Reconyx, Bushnell, and Woodland Outdoor Sport) and were deployed at all sites where signs of otters were found. These were attached to trees approximately 50 cm above the ground, on branches over the water, or on floating logs and vegetation. Camera traps were typically left in place for 3–4 weeks, and at some locations were used several times during the year. Habitats at the survey sites were described and recorded.

Results

Our surveys confirm the presence of the hairy-nosed otter in four areas of Cambodia: Tonle Sap Lake, Cardamom Mountains, coastal areas in Koh Kong province, and Bassac Marsh. No evidence of the species was found at

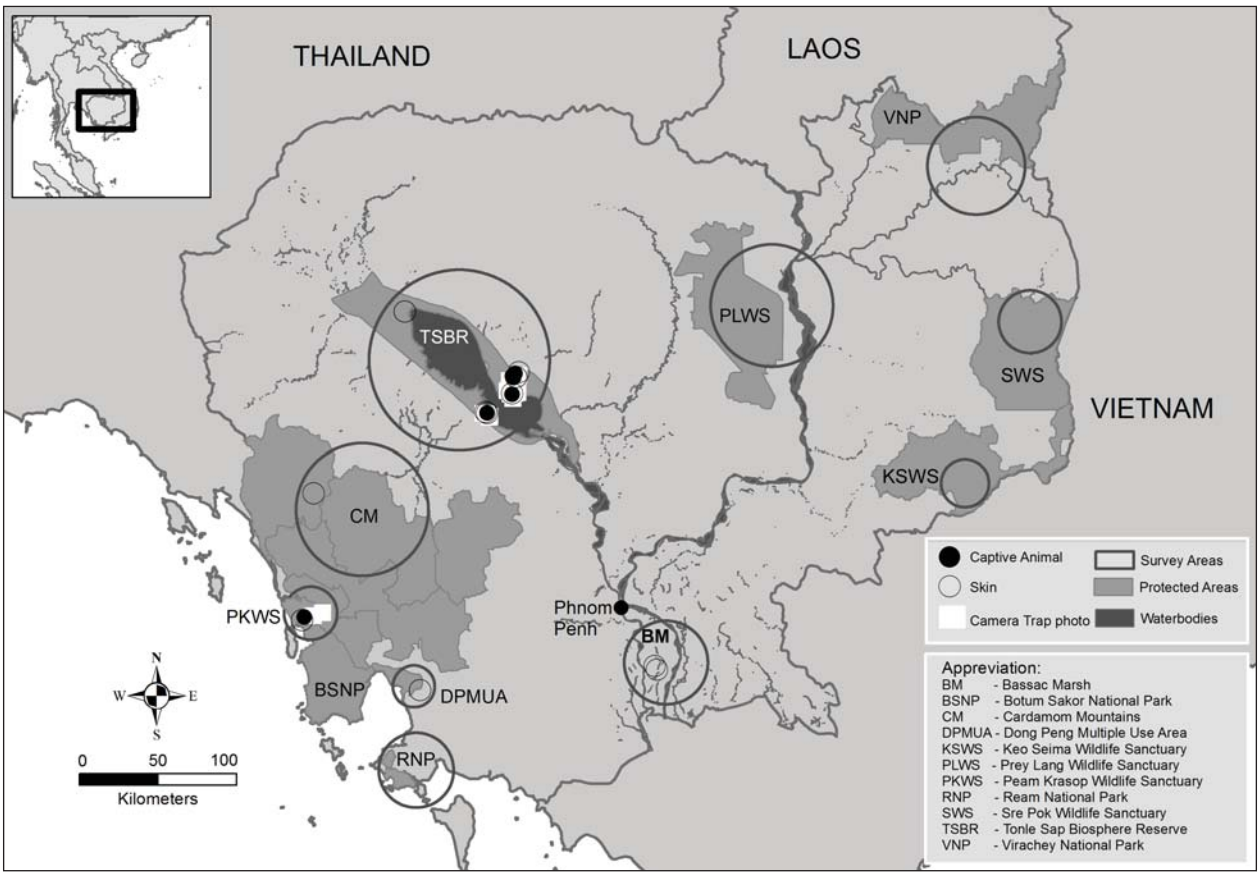

Fig. 1 Survey areas and confirmed records for hairy-nosed otter *Lutra sumatrana* in Cambodia.

Table 1 Survey effort and confirmed records for the hairy-nosed otter and other otter species in Cambodia. LS = hairy-nosed otter *Lutra sumatrana*; LP = smooth-coated otter *Lutrogale perspicillata*; AC = Asian small-clawed otter *Aonyx cinereus*.

Survey Area	Survey Year	No of Sites Surveyed	Habitat Types	No of Camera Locations	No of Camera Trap Photos			No of Skins			No of Live Individuals		
					LS	LP	AC	LS	LP	AC	LS	LP	AC
Northeast Cambodia	2006–2010	6	Hill & lowland evergreen forest	18		19	3		1	10			
Bassac Marsh	2008	1	Wetlands and flooded forest	0				2					
Mekong River	2007–2008	2	Lowland evergreen forest	7		10			1				
Cardamom Mountains	2006–2009	10	Hill & lowland evergreen forest	46		1		1					
Tonle Sap Lake	2006–2013	5	Wetlands and flooded forest	118	66	169		10	6		7		
Coastal Region	2006–2012	6	Mangrove & *Melaleuca* forest	39	5	322		5	3		1		

other survey sites, which included the lowland evergreen and swamp forests of Prey Long Wildlife Sanctuary and riparian sites along the Mekong River in the Kratie and Stung Treng provinces, and riparian forest along the Sre Pok River and tributaries in northeast Cambodia in the Ratanakiri and Mondulkiri provinces.

Records of hairy-nosed otter comprised eight live captive individuals and 18 skins found in local houses and 71 camera trap photographs (Table 1). Of the 228 locations surveyed with camera traps, hairy-nosed otter was confirmed at 26 (Fig. 1). Smooth-coated otter *Lutrogale perspicillata* was also recorded at all sites where hairy-nosed otters were confirmed and these two species evidently live sympatrically in parts of their ranges. Smooth-coated otter was also recorded from the Sre Pok River and Asian small-clawed otter *Aonyx cinereus* at sites within and nearby Virachey National Park.

Most records of hairy-nosed otter were from Tonle Sap Lake, where ten skins, 66 camera trap photographs, and seven live individuals were registered (Table 1). Results from the camera trap and sign surveys suggest that the species here is mostly associated with gallery forest habitat with wide canopies during the wet season. Spraints were found mostly on the following tree species: *Xanthophyllm glacum*, *Terminalia cambodiana*, *Coccoceras anisopodum, Barringtonia acutangula* and *Combretum trifoliatum*, and individuals were caught on camera moving about the branches of these trees (Fig. 2). In the dry season when waters subside, hairy-nosed otters were predominantly recorded along streams and ponds in areas of the the floodplain that still contained water.

Most of the records (camera trap photos, scat, skins and live animals) from Tonle Sap Lake were from Boeng Tonle Chmmar, a Ramsar site and one of three core zones of the Tonle Sap UNESCO Man and Biosphere Reserve. This area contains some of the best remaining habitat for the species at Tonle Sap, with intact and dense high-canopy flooded forests and scrub. Interviewees reported that fish diversity and abundance is high, and the area also supports seasonal colonies of water birds that use the site for feeding and nesting.

Two hairy-nosed otter skins were recorded during interviews at local houses in Bassac Marsh, both of which came from animals that had been by-catch in fishing gear. One of the interviewees previously acted as a middleman, buying otter skins from villagers and selling these onwards to traders. This individual and other interviewees reported that local otter populations were declining due to development and hunting. Otters are sometimes seen in the swamp forest by local residents and are occasionally caught in fishing gear. A single hairy-nosed otter skin was also found in a household near the Takong stream in the Veal Veng district of the Cardamom Mountains. This animal had been caught by dogs near the stream between 700–800 m asl (above sea level) during the dry season when the stream contained little water. Packs of three to six dogs are regularly used by villagers to hunt mammals and reptiles such as otters, turtles, and lizards.

Hairy-nosed and smooth-coated otters were both recorded in the coastal region, with most records being of the latter. Records of hairy-nosed otters comprised five camera trap photographs, five skins, and one live individual kept as a pet, whereas smooth-coated otter records comprised 322 camera trap photographs and three skins (Table 1).

Discussion

Distribution and habitat use

Our data suggests hairy-nosed otters inhabit several habitats in Cambodia, namely flooded forest and scrub around the Tonle Sap Lake, marshland and coastal mangrove and *Melaleuca* forest. This matches the findings of Kanchanasaka *et al.* (1998, 2003) who found the species in peat swamp and *Melaleuca* forest in Thailand, as well as Nguyen *et al.* (2001) and Nguyen (2005) who found it in the low-lying peat swamp forests of U Minh Thuong Nature Reserve near the Cambodian border in Vietnam. Hairy-nosed otter also occurs in coastal areas in Indonesia, especially in mangrove forest (Hussain *et al.*, 2008). Sivasothi & Burhanuddin (1994) suggest the species may inhabit streams >300 m asl in Malaysia, although most records in the Cardamom Mountains appear to be from lakes and wetlands at lower elevations. Our findings also match those of Heng (2010), who found the species inhabits flooded forest and scrub around the Tonle Sap Lake, using ponds and drainage canals in the dry season.

Our results indicate that hairy-nosed otters and smooth-coated otters share the same habitats in the Tonle Sap Lake. However, smooth-coated otters were more often found in open habitats such as floating logs and bare river/lake banks, whereas hairy-nosed otters appeared to prefer areas sheltered by trees and vegetation such as gallery forest and scrublands (Heng, 2010). Heng (2010) also recorded both species at the same sites in Tonle Sap Lake, as did Kanchanasaka *et al.* (1998) in peat swamp forest in Thailand.

Fig. 2 Hairy-nosed otter in flooded scrub at Tonle Sap Lake on 23 September 2008 (© Conservation International).

Fig. 3 Pregnant female hairy-nosed otter at Tonle Sap Lake on 18 March 2012 (© Conservation International).

Fig. 4 Hairy-nosed otter with cubs at Tonle Sap Lake on 20 April 2013 (© Conservation International).

Previous records from Cambodia

The first record of hairy-nosed otter was of two captive otters photographed in 1998 by Frederic Goes at Prek Toal village in the floodplain of Tonle Sap Lake (Poole, 2003). A mounted specimen was found at Phnom Tamao Zoo (now Phnom Tamao Zoological Park and Wildlife Rescue Center, PTWRC) in 1999, which may have originated from Mondulkiri province (although this remains unconfirmed). In 2000, a live hairy-nosed otter was photographed at Sre Khlong village, Kompong Speu Province, which reportedly originated from the area (unconfirmed). Poole (2003) also reported secondary records of the species from *Melaleuca* swamp forests north and west of Sre Ambel in Koh Kong province. In addition, unconfirmed records of the species at Tonle Sap Lake are included in several reports (Bonheur, 1997; Goes, 2005; Davidson, 2006). Holden & Thy (2009) reported a skin of hairy-nosed otter found at a hunter's house in Chhe Teal Chrum village, Pursat Province. This was reportedly caught in 2006 from the Ang Krang River at the foot of Phnom Samkos in the Cardamom Mountains. The Ang Krang is a small stream which flows through hilly primary and secondary forest at approximately 400 m asl. Holden & Thy (2009) also reported camera trap photos of hairy-nosed otters from Veal Veng marsh at 560 m asl in the Cardamom Mountains between 2007 and 2008.

Most of the above records fall within the same regions where we recorded the species. We suspect the reason for the relative paucity of hairy-nosed otter records in Cambodia is due to a combination of the species being naturally shy and secretive (compared to smooth-coated otter for instance), its natural occurrence at low densities and probably solitary nature, coupled with confusion with other otter species and the fact that areas where the species is now confirmed have been little surveyed until recently, due to their poor accessibility and years of civil conflict.

Breeding

Most of our camera trap photographs were of a single individual, which suggests that the hairy-nosed otter is mainly solitary, similar to the Eurasian otter *Lutra lutra* (Yoxon & Yoxon, 2014). Only eight of our photographs were of two adults, whereas one set of photographs showed two adults with two cubs and three sets were of a female with cubs. As the latter were taken within weeks of each other in the same area, these may represent a family group comprising one female and three cubs.

The breeding season of the hairy-nosed otter in Cambodia is unclear. Wright *et al.* (2008) concluded that the gestation period for hairy-nosed otters (and other

otter species) is approximately two months. Our camera traps recorded hairy-nosed otters in pairs between November and March, which could indicate mating activity. A heavily pregnant female was captured on camera at Tonle Sap Lake in March (Fig. 3) and a dead female with four unborn fetuses was photographed in a cylinder fish trap by our team at Tonle Sap Lake in June. Camera trap photographs of hairy-nosed otters with cubs occurred in April (Fig. 4), and cubs were reportedly caught by fishermen in July. One fisherman caught a juvenile hairy-nosed otter in coastal *Melaleuca* forest in November, although interviewees also reported seeing unknown otter species with cubs throughout the year. These records collectively suggest that the hairy-nosed otter may give birth towards the end of and just after the dry season between April and June. During this period, water levels are low and prey fish are concentrated in smaller, restricted water bodies such as dry season ponds, oxbow lakes, and deep river pools, and may therefore be easier to catch. This period may also provide better access to land where dens can be established, particularly at Tonle Sap Lake. Despite extensive survey effort, holts and resting areas used by hairy-nosed otters have yet to be found in Cambodia however, so the kind of den used by the species in the country remains unknown.

Activity patterns

Although camera traps recorded hairy-nosed otters at all times of day and night, most photographs were taken between 17:00 and 01:00 hrs, suggesting the species is most active during this time. In contrast, smooth-coated otters were equally active during the day and night at our survey sites.

Conservation threats and recommendations

Hairy-nosed otters have been confiscated from or donated by hunters and fishermen on several occasions in Cambodia. Some of these individuals have been released, but when injured or deemed unhealthy, others have been transferred to the PTWRC.

In November 2008, one hairy-nosed otter was caught and kept as a pet by a fisherman near Koh Kong Khnong village in Kong Kong Province, but later confiscated and brought to PTWRC. In June 2009, one animal caught by a fisherman near a dry season pond in the Boeng Tonle Chmmar area of Tonle Sap Lake was confiscated and brought to PTWRC. Four adult individuals were also caught at Boeng Tonle Chmmar in 2010 and 2011, and subsequently released. In July 2010, two sub-adult animals left by their mother along a stream were caught by a fisherman from Anlong Rieng village near Kompong Prak Fish Sanctuary, Pursat Province and also released.

All otter species in Cambodia are threatened by illegal wildlife trade, destruction of habitats, loss of food sources, and persecution as pests. Otter fur is popular for use in fashion and traditional clothing, particularly in China, and because pelts fetch high prices on the illegal market (Bennetto, 2009), this demand threatens otters throughout Asia. In Cambodia, a good quality pelt can sell for up to US$200 and this creates a strong incentive for fishermen and hunters to target otters (Heng, 2010).

Degradation and conversion of wetlands and wet forests into rice fields, shrimp farms, and other land uses is steadily reducing habitat for otters, while overfishing is depleting their food sources. Otters are often targeted and killed by fishermen who view them as pests that compete for fish and damage fishing gear. Additionally, disturbance of wetlands has escalated as human populations increase in neighbouring areas, which raises a concern for shy and secretive species such as the hairy-nosed otter. More broadly, as climate change and infrastructure development on the Mekong River, its tributaries, and in the delta are altering water flows and ecological processes, this will impact otters and other wildlife that depend on these ecosystems (MRC, 2010). If action is not taken to preserve the habitats used by hairy-nosed otter and to combat illegal wildlife trade, extinction of this species, as previously feared in 1998, will likely become a reality. In clarifying the current range of hairy-nosed otter in Cambodia, our study should aid development of conservation and management plans for the species nationally.

Tonle Sap Lake is linked to the Bassac Marsh by the Mekong River which in turn connects to the U Minh Thuong wetlands in Vietnam. Our finding that the hairy-nosed otter occurs at all of these sites is to be expected given the presumed historical range of the species. Existing records from the northern side of the Cardamom Mountains are from streams and wetlands drained by the Pursat River, which originates in the mountains and flows into the Tonle Sap Lake. As rivers on the southern side of the Cardamom Mountains in Koh Kong province belong to a different catchment, populations of hairy-nosed otter inhabiting these waterways are unlikely to be connected to the population at Tonle Sap Lake. Historically however, the species likely occurred all along the east coast of Thailand through Cambodia and Vietnam (Wright *et al.,* 2008). We recommend further surveys in suitable habitats along the Mekong River between the Tonle Sap Lake and the Vietnamese border and at coastal sites such as Ream National Park to improve under-

standing of the distribution and status of hairy-nosed otter in Cambodia.

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References

Aadrean, A., Kanchanasaka, B., Heng S., Reza Lubis, I., de Silva, P. & Olsson, A. (2015) *Lutra sumatrana. The IUCN Red List of Threatened Species*. Http://dx.doi.org/10.2305/IUCN.UK.2015-2.RLTS.T12421A21936999.en [accessed 29 October 2016].

Arias, M.E., Cochrane, T. , Norton, D., Killeen, T.J. & Khon P. (2013) The flood pulse as the underlying driver of vegetation in the largest wetland and fishery of the Mekong Basin. *AMBIO*, **42**, 864–876.

Bennetto, C. (2009) International training workshop on Asian otter research and conservation. *IUCN Otter Specialist Group Bulletin*, **26**, 65–131.

Bonheur, N. (1997) *An action plan for natural resource and environmental management in the Mekong river basin of Cambodia including Tonle Sap system*. Ministry of Environment, Phnom Penh, Cambodia.

Campbell, I.C., Poole, C., Giesen W. & Valbo-Jorgensen, J. (2006) Species diversity and ecology of Tonle Sap Great Lake, Cambodia. *Aquatic Sciences*, **68**, 355–373.

Constable, D. (2015) *The Sesan and Sre Pok River Basins*. IUCN Asia Regional Office, Bangkok, Thailand.

Davidson, J.A. (2006) *The biodiversity of the Tonle Sap Biosphere Reserve, 2005 status review*. Unpublished report to Wildlife Conservation Society, Phnom Penh, Cambodia.

Dong T., Tep M., Lim S., Soun S. & Chrin T. (2010) Distribution of otters in the Tropeang Roung, Koh Kong Province, Cambodia. *IUCN Otter Specialist Group Bulletin*, **27**, 63–77.

Goes, F. (2005) *Four years of waterbird conservation activities in Prek Toal Core Area, Tonle Sap Biosphere Reserve (2001-2004)*. Unpublished report to Wildlife Conservation Society, Phnom Penh, Cambodia.

Heng S. (2010) Factors affecting site selection and feeding habits of hairy-nosed otter *Lutra sumatrana* and smooth-coated otter *Lutrogale perspicillata* at Tonle Sap Great Lake, Cambodia. *Cambodian Journal of Natural History*, **2010**, 63–65.

Holden, J. & Thy N. (2009) Small carnivore records from the Cardamom Mountains, southwestern Cambodia. *Small Carnivore Conservation,* **40**, 16–21.

Hon N., Neak P., Khov V. & Cheat V. (2010) Food and habitat of Asian small-clawed otter in northeastern Cambodia. *IUCN Otter Specialist Group Bulletin*, **27**, 12–23.

Hussain, S.A. & Choudhury, B.C. (1997) Distribution and status of the smooth-coated otter *Lutrogale perspicillata* in National Chambal Sanctuary, India. *Biological Conservation*, **80**, 199–206.

Hussain, S.A., Kanchanasaka, B., de Silva, P.K., & Olsson, A. (2008) *Lutra sumatrana. The IUCN Red List of Threatened Species*. Http://www.iucnredlist.org/ [accessed 14 October 2014].

Kanchanasaka, B. (2000) The status of otters in Thailand and a note on the discovery of three hairy-nosed otter (*Lutra sumatrana*) cubs. In *Proceedings of the Workshop on Conservation and Public Awareness of Otters* (eds C. Santiapillai & Sasaki H.), pp 110–113. Otter Research Group, Fukuoka, Japan.

Kanchanasaka, B. & Duplaix, N. (2013) Food habits of the hairy-nosed otter (*Lutra sumatrana*) and the small-clawed otter (*Aonyx cinereus*) in Pru Toa Daeng Peat Swamp Forest, southern Thailand. *IUCN Otter Specialist Group Bulletin,* **28A**, 139–161.

Kanchanasaka, B., Simcharoen, S. & Than, U.T. (1998) *Carnivores of Mainland South East Asia*. WWF-Thailand, Bangkok, Thailand.

Kanchanasaka, B., Arsai, D. & Thumchimplee, C. (2003) *Status and distribution of the hairy-nosed otter (*Lutra sumatrana*) in Thailand*. Unpublished report to Wildlife Research Division, National Parks, Wildlife and Plant Conservation Department, Royal Forest Department, Bangkok, Thailand.

Kanchanasaka, B. (2001) Tracks and other signs of the hairy-nosed Otter (*Lutra sumatrana*). *IUCN Otter Specialist Group Bulletin,* **18**, 57–63.

Keo O. & Evans, T. (2013) *Reduced emissions from deforestation and degradation in Seima Protection Forest*. Unpublished report to Wildlife Conservation Society and the Forestry Administration, Phnom Penh, Cambodia.

McDonald, J.A., Bunnat P., Virak P. & Bunton, L. (1997) *Plant communities of the Tonle Sap floodplain*. Unpublished report to UNESCO, IUCN and Wetlands International, Phnom Penh, Cambodia.

MRC (2010) *State of the Basin Report 2010*. Mekong River Commission, Vientiane, Laos.

Nguyen X.D., Pham T.A. & Le H.T. (2001) New information about the hairy-nosed otter (*Lutra sumatrana*) in Vietnam. *IUCN Otter Specialist Group Bulletin,* **18**, 64–75.

Nguyen X.D. (2005) Current status of otters (Mammalia: Lutrinae) in Viet Nam with conservation implications. *Tigerpaper*, **33**, 8–14.

Olsson, A. (2009) International training workshop on Asian otter research and conservation, February 24 to March 3, 2009 in Cambodia. Unpublished report to Conservation International, Phnom Penh, Cambodia.

Olsson, A. & Emmett, D. (2007) *A floral and faunal biodiversity assessment of Prey Long*. Unpublished report to Conservation International, Phnom Penh, Cambodia.

Poole, C.M. (2003) The first records of hairy-nosed otter *Lutra sumatrana* from Cambodia with notes on the national status of three other otter species. *Natural History Bulletin of the Siam Society*, **51**, 273–280.

Poulsen, A., Ouch P., Sintavong, V., Ubolratana, S. & Nguyen T. (2002) *Deep pools as dry season fish habitats in the Mekong Basin*. MRC Technical Paper No. 4, Mekong River Commission, Phnom Penh, Cambodia.

Sivasothi, N. & Burhanuddin, H.M.N. (1994) A review of otters (Carnivora: Mustelidae: Lutrinae) in Malaysia and Singapore. *Hydrobiologia*, **285**, 151–170.

UNEP (2008) *National reports on wetlands in the South China Sea*. UNEP/GEF/SCS Technical Publication No. 13, United Nations Environment Programme, Bangkok, Thailand.

Wright, L., Olsson, A. & Kanchanasaka, B. (2008) A working review of the Hairy-nosed otter (*Lutra sumatrana*). *IUCN Otter Specialist Group Bulletin*, **25**, 38–59.

Yoxon, P. & Yoxon, G.M. (2014) *Otters of the World*. Whittles Publishing, Scotland, UK.

Yoxon, P. & Yoxon, G. (2007) *Otters – the forgotten victims of wildlife crime*. International Otter Survival Fund, Scotland, UK.

Short Communication

New provincial record and range extension of the parachute gecko *Ptychozoon lionotum* Annandale, 1905 in Cambodia, with notes on habitat use

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Parachute geckos, genus *Ptychozoon*, are small to medium sized arboreal geckos known for their enigmatic gliding behaviour (Heyer *et al.,* 1970; Young *et al.,* 2002). The genus consists of nine recognized species distributed from eastern India (Pawar & Biswas, 2001) and southern China (Wang *et al.,* 2016) in the north, southwards through Indochina (Taylor, 1963) and the Malay Peninsula (Grismer, 2011) to the Greater Sunda Islands (Min & Das, 2012). *Ptychozoon* species are also known from the Nicobar Islands (Das & Vijayakumar, 2009) and the Philippine Archipelago (Brown *et al.,* 1997). The geographic distribution of this poorly known genus is only now beginning to be reliably understood, and significant gaps in knowledge remain (Brown *et al.,* 2012). Two species of *Ptychozoon* are known from Cambodia, each of which was first recorded recently (within the last decade) and both on the basis of only a single locality (Stuart & Emmett, 2006; Hartmann *et al.,* 2014).

The rare *Ptychozoon trinotaterra* is known from Cambodia on the basis of a single specimen photographed at Preah Khan Temple in Siem Reap Province (Hartmann *et al.,* 2014) (Fig. 1). The smooth-backed parachute gecko *P. lionotum* is known in Cambodia from four specimens collected by Stuart & Emmett (2006) at a single locality in Kirirom National Park in the Cardamom Mountains of southwestern Cambodia (Fig. 1). Here we present the second known locality for *P. lionotum* in Cambodia, and substantially extend the known range of the species within the country.

On 30 May 2016 at approximately 1130 hrs, DSL observed a single unsexed adult *P. lionotum* in a cleared parking area approximately 160 meters west of Phnom Kulen Waterfall, Phnom Kulen National Park, Svay Leu District, Siem Reap Province (Fig. 1). The individual was observed when it glided from a nearby tree, landing on the shirt of a startled tourist bystander who quickly brushed it off. Once on the ground the lizard was photographed and the specimen was later identified on the basis of the photograph (Fig. 2).

The individual was positively identified as *P. lionotum* on the basis of: 1) four dark dorsal chevrons between the axilla and the groin (versus three in *P. trinotaterra* and *P. kaengkrachanense*); and, 2) a non-expanded tail terminus (as opposed to *P. kuhli*, which possesses a widely expanded terminal flap: Brown *et al.,* 1997). This identification was verified by Rafe M. Brown (University of Kansas Biodiversity Institute) and the photo voucher was deposited in the University of Kansas Digital Archives (KUDA 012461).

This new locality extends the known distribution of *P. lionotum* in Cambodia approximately 250 km north from the only other known locality in Kirirom National Park in the Cardamom Mountains (Stuart & Emmett, 2006).

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Fig. 1 Localities of parachute geckos, genus *Ptychozoon*, recorded in Cambodia: *P. lionotum* (solid circle), Kirirom National Park (Stuart & Emmett, 2006); *P. trinotaterra (*solid square), Angkor Temple complex (Hartmann *et al.,* 2014); *P. lionotum (*open circle), Phnom Kulen National Park (this study).

Fig. 2 Dorsal view of adult *Ptychozoon lionotum* (KUDA 012461) from Phnom Kulen National Park, Siem Reap Province, Cambodia (© Deborah Lee).

This substantial extension indicates that *P. lionotum* is likely to occur throughout the country in areas where appropriate evergreen or semi-evergreen forest habitat persists. Outside of Cambodia, *P. lionotum* is known from extreme eastern India (Pawar & Biswas, 2001), Myanmar (including the type locality: Pegu, Myanmar; Annandale, 1905; Smith, 1935), Thailand (Taylor, 1963), Peninsular Malaysia (Das & Yaakob, 2005; Grismer, 2011), and southern Vietnam (Nguyen *et al.,* 2009). To our knowledge, the species is not known from Laos, but given the proximity of this new locality (ca. 140 km southwest of the Laotian border) it is possible that future surveys may reveal its presence there as well.

Interestingly, our individual was encountered in a small disturbed area (a parking lot) within a forested national park. This observation mirrors earlier reports of *P. lionotum* being encountered near sites of anthropogenic disturbance, but within protected areas (Stuart & Emmett, 2006). Brown (1999) mentions that, with the exception of the disturbance-tolerant *P. kuhli*, the paucity of records for most *Ptychozoon* species is likely a result of their being forest canopy obligates which are rarely encountered. We agree with this assertion, but add that within such forest habitats *Ptychozoon* species may be tolerant of small scale disturbance and may utilize edge habitats and man-made structures with some frequency (Grismer, 2011; Sumontha *et al.,* 2012). The paucity of records may therefore be first and foremost a function of the highly cryptic nature of these animals.

References

Annandale, N. (1905) Notes on some Oriental geckos in the Indian Museum, Calcutta, with descriptions of new forms. *Annals and Magazine of Natural History*, **15**, 26–32.

Brown, R.M. (1999) New species of parachute gecko (Squamata: Gekkonidae: genus *Ptychozoon*) from northeastern Thailand and central Vietnam. *Copeia*, **4**, 990–1001.

Brown, R.M., Ferner, J.W. & Diesmos, A.C. (1997) Definition of the Philippine parachute gecko, *Ptychozoon intermedium* Taylor 1915 (Reptilia: Squamata: Gekkonidae): redescription, designation of a neotype, and comparisons with related species. *Herpetologica*, **53**, 357–373.

Brown, R.M., Siler, C.D., Grismer, L.L., Das, I. & McGuire, J.A. (2012) Phylogeny and cryptic diversification in Southeast Asian flying geckos. *Molecular Phylogenetics and Evolution*, **65**, 351–361.

Das, I. & Norsham, Y. (2007) Status of knowledge of the Malaysian herpetofauna. In *Status of Biological Diversity in Malaysia and Threat Assessment of Plant Species in Malaysia* (eds L.S.L. Chua, L.G. Kirton & Saw L.G.), pp. 31–81. Forest Research Institute, Kepong, Selangor, Malaysia.

Das, I. & Vijayakumar, S.P. (2009) New species of *Ptychozoon* (Sauria: Gekkonidae) from the Nicobar Archipelago, Indian Ocean. *Zootaxa*, **2095**, 8–20.

Grismer, L.L. (2011) *Lizards of Peninsular Malaysia, Singapore, and Their Adjacent Archipelagos: Their Description, Distribution, and Natural History*. Edition Chimaira, Frankfurt, Germany.

Hartmann, T., Bets, A.B., De Greef, S. & Ihlow, F. (2014) First record of the rare parachute gecko *Ptychozoon trinotaterra* Brown, 1999 from Cambodia. *Cambodian Journal of Natural History*, **2014**, 12–13.

Heyer, W.R. & Pongsapipatana, S. (1970) Gliding speeds of *Ptychozoon lionatum* (Reptilia: Gekkonidae) and *Chrysopelea ornata* (Reptilia: Colubridae). *Herpetologica*, **26**, 317–319.

Min, P.Y. & Das, I. (2012) A significant range extension for the Kinabalu parachute gecko, *Ptychozoon rhacophorus* (Boulenger, 1899) (Squamata: Gekkonidae) and a new state record from Sarawak, northwestern Borneo. *Herpetology Notes*, **5**, 177–179.

Nguyen V.S., Ho T.C. & Nguyen Q.T. (2009) *Herpetofauna of Vietnam*. Edition Chimaira, Frankfurt, Germany.

Pawar, S.S. & Biswas, S. (2001) First record of the smooth-backed parachute gecko *Ptychozoon lionotum* Annandale 1905 from the Indian mainland. *Asiatic Herpetological Research*, **9**, 101–106.

Smith, M.A. (1935) *The Fauna of British India, Including Ceylon and Burma. Reptilia and Amphibia. II. Sauria*. Taylor & Francis, London, UK.

Stuart, B.L. & Emmett, D.A. (2006) A collection of amphibians and reptiles from the Cardamom Mountains, southwestern Cambodia. *Fieldiana Zoology*, **109**, 1–27.

Sumontha, M., Pauwels, O., Kunya, K., Limlikhitaksorn, C., Ruksue, S., Taokratok, A., Ansermet, M. & Chanhome, L. (2012) A new species of parachute gecko (Squamata: Gekkonidae: genus *Ptychozoon*) from Kaeng Krachan National Park, western Thailand. *Zootaxa*, **3513**, 68–78.

Taylor, E.H. (1963) The lizards of Thailand. *University of Kansas Science Bulletin*, **44**, 687–1077.

Wang Y.Y., Wang J. & Liu Z.Y. (2016) Description of a new species of the genus *Ptychozoon* (Squamata: Gekkonidae), representing a new national record of this genus from southern Yunnan Province, China. *Zootaxa*, **4084**, 406–420.

Young, B.A., Lee C.E. & Daley, K.M. (2002) On a flap and a foot: aerial locomotion in the "flying" gecko, *Ptychozoon kuhli*. *Journal of Herpetology*, **36**, 412–418.

Short Communication

First record of the Buonluoi forest skink *Sphenomorphus buenloicus* Darevsky & Nguyen, 1983 (Squamata: Scincidae) from Cambodia

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The family Scincidae (skinks) is a globally diverse group of lizards with 154 genera and 1,605 species currently recognised worldwide (Uetz *et al.,* 2016). Among these genera, the genus *Sphenomorphus* Fitzinger, 1843 currently comprises 109 species following recent taxonomic revisions which have transferred numerous species of *Sphenomorphus* to the newly established genera *Tytthoscincus* and *Pinoyscincus* (Linkem *et al.,* 2011; Grismer *et al.,* 2016) and back-and-forth placement of taxa between the morphologically similar genera *Sphenomorphus*, *Leptoseps*, *Livorimica*, *Paralipinia*, *Lipinia,* and *Scincella* (Darevsky, 1990; Nguyen *et al.,* 2011).

Sphenomorphus skinks occur from India to Southeast Asia, the Philippines and Australia and associated islands (Grismer *et al.,* 2008; Nguyen *et al.,* 2011; Datta-Roy *et al.,* 2013; Uetz *et al.,* 2016). They are distinguished by the combination of the following morphological characters: the absence of supranasal scales; the presence of prefrontals; parietals in contact posteriorly; lower eyelid scaly; tympanum deeply sunk; five digits on hind limbs; less than 30 subdigital lamellae on the fourth toe; inner precloacal scales overlapping the outer precloacal scales; median pair of precloacal scales enlarged; two or more scale rows of supra-digital scales on the dorsal surface of the fourth toe; and the presence of long thin and bifurcated hemipenes (Taylor, 1963; Lim, 1998; Grismer, 2008; Nguyen *et al.,* 2011). Following the allocation of *Sphenomorphus rufocaudatus* to the genus *Scincella* (Darevsky, 1990; Nguyen *et al.,* 2011), which we follow herein, the genus *Sphenomorphus* is represented by only four species in Cambodia: *S. indicus* (Gray, 1853), *S. lineopunctulatus* Taylor, 1962, *S. maculatus* (Blyth, 1853), and *S. stellatus* (Boulenger, 1900) (Grismer *et al.,* 2008; Hartmann *et al.,* 2010).

Phnom Namlyr Wildlife Sanctuary is located in the eastern plains of Cambodia beside the Vietnamese border in Mondulkiri Province (Fig. 1, locality 9). Knowledge of the herpetofauna of this area is very limited as only one survey has been undertaken there since 2000 (Stuart *et al.,* 2006). During a field visit to the wildlife sanctuary on 29 December 2014, the first author collected three skink specimens which could not be assigned to any of the four *Sphenomorphus* species currently known from Cambodia: CBC02769–70, two males; CBC02771 – one female (coordinates: 12°19′26.2″N, 107°23′38.0″E). One specimen (CBC02769) was encountered moving among leaf litter on a forest trail while the remaining two (CBC02770–71) were found underneath rotten logs. All were found during the day in evergreen forest between 10:30 and 14:20 hrs. The specimens were preserved in 10% formalin

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and later transferred to 70% ethanol and deposited in the zoological collection of the Royal University of Phnom Penh, Cambodia. Examination of morphometric and meristic characters followed Darevsky & Nguyen (1983) and Nguyen *et al.* (2011).

The morphometric and meristic characters of the three *Sphenomorphus* specimens match those of *S. buenloicus* Darevsky & Nguyen, 1983, including the following (all measurements are given in mm): snout to vent length 53.2–56.1; tail length 25.8–30; prefrontals in contact; lower eyelids scaly; supraciliaries 10–13; supralabials 7, the 4th and 5th located underneath the eye; infralabials 6; primary temporal 1; supraocular 4; parietals in contact posteriorly; mid-body scale rows 32–34; ventral scales 62–66; limbs well-developed, each with 5 digits; subdigital lamellae under fourth toe 17–21; hemipenis bifurcating near the tip. In life (Fig. 2), Cambodian specimens have reddish brown colouration on the dorsum, flanks, and tail; scattered, small dark spots on the dorsum and labial region; an indistinct dark stripe from the nostril to the anterior corner of eye, passing the postocular and temporal region and running along the dorsolateral region to the base of tail; lower flanks, especially in the axillary region reddish-brown, with pinkish spotting in the region between posterior axilla and body; scattered tiny elongated light bars along the body and tail flanks; and dorsal surface of limbs with dark blotches. The colouration of specimens of *S. buenloicus* from Mondulkiri Province (Fig. 2A) is quite similar to that of the population from the type locality in Gia Lai Province, Vietnam (Fig. 2B).

Cambodian specimens differ slightly from *S. buenloicus* specimens from the type locality in certain morphological attributes based on the original description by Darevsky & Nguyen (1983): e.g., in having 10–13 supraciliaries (versus 9 in *S. buenloicus*); 32–34 mid-body scale rows (versus 30–34 in *S. buenloicus*); and 62–66 ventral scales (versus 55–58 in *S. buenloicus*). These differences may be due to population variation; however further studies including examination of genetic differentiation are required to understand the taxonomic importance of morphological differences between Cambodian and Vietnamese populations of *S. buenloicus*.

Sphenomorphus buenloicus was originally described from Buon Luoi in Gia Lai-Kon Tum Province of Vietnam (now Gia Lai Province, forest in the type locality is destroyed; Fig. 1, locality 7) and later reported from several localities in the mountainous regions of Tay Nguyen Plateau in Gia Lai and Kon Tum provinces of Vietnam (Fig. 1, localities 3–8). It was also recorded in Chu Mom Ray National Park in Kon Tum Province (Fig. 1, locality 3), adjacent to Virachey National Park

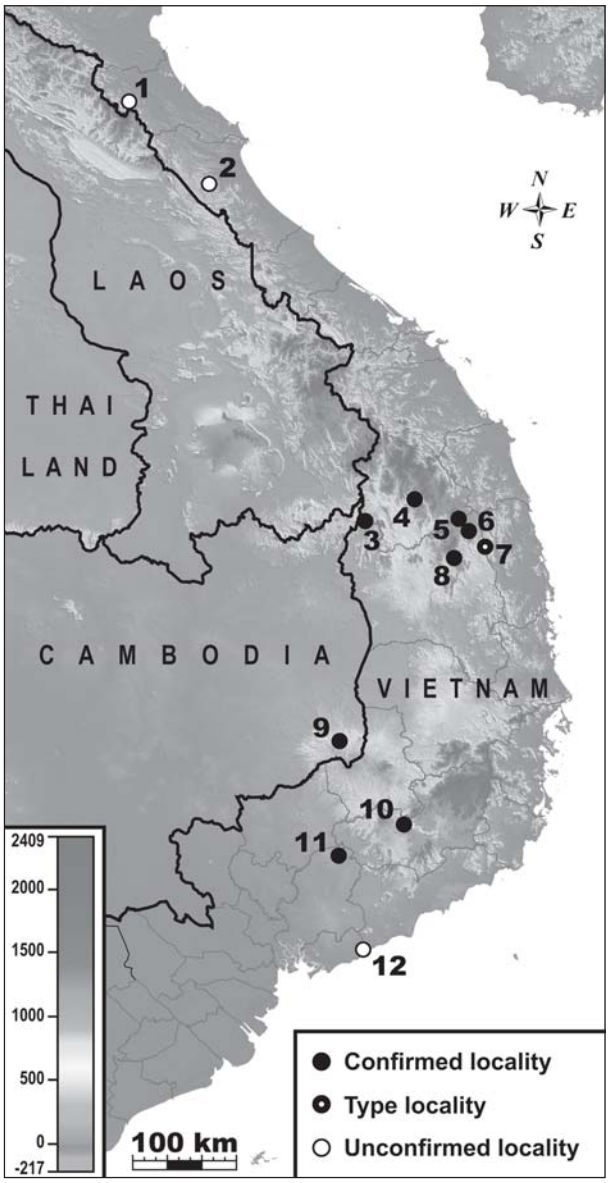

Fig. 1 Known distribution of *Sphenomorphus buenloicus* in Vietnam and Cambodia: 1) Vu Quang N.P., Ha Tinh (Nguyen *et al.*, 2009); 2) Phong Nha-Ke Bang N.P., Quang Binh (Ziegler *et al.*, 2006; Nguyen *et al.*, 2009); 3) Chu Mom Ray N.P., Kon Tum (Jestrzemski *et al.*, 2013); 4) Kon Plong, Kon Tum (Nguyen *et al.*, 2009); 5) Kon Chu Rang N.R., Kon Ha Nung Plateau, Gia Lai (Bobrov & Semenov, 2008; Poyarkov, unpublished data); 6) So Pai, K Bang, Gia Lai (Nguyen *et al.*, 2009); 7) Buon Luoi, An Khe, Gia Lai (type locality, Darevsky & Nguyen, 1983); 8) Kon Ka Kinh N.P., Gia Lai (Bobrov & Semenov, 2008; Poyarkov, unpublished data); 9) Phnom Namlyr W.S., Mondulkiri (this study); 10) Loc Bac, Lam Dong (Vassilieva *et al.*, 2016; Poyarkov, unpublished data); 11) Nam Cat Tien, Dong Nai (Vassilieva *et al.*, 2016); 12) Binh Chau–Phuok Buu N.P., Ba Ria–Vung Tau (Nguyen *et al.*, 2009).

Fig. 2 *Sphenomorphus buenloicus* in life: A) adult male from Phnom Namlyr Wildlife Sanctuary, Mondulkiri, Cambodia; B) adult male from Kon Chu Rang Nature Reserve, Gia Lai, Vietnam (© Neang Thy & Nikolay Poyarkov).

in Cambodia. Recently, *S. buenloicus* was found in the Loc Bac forest, Lam Dong Province (Fig. 1, locality 10) and Nam Cat Tien National Park, Dong Nai Province of Vietnam (Fig. 1, locality 11). The hilly area of the Lam Dong and Dong Nai provinces share many herpetofaunal elements with hilly areas in the eastern area of Mondulkiri Province, Cambodia (Fig. 1, locality 9; Stuart *et al.*, 2006). However, as some localities where *S. buenloicus* has been recorded in the northern part of central Vietnam (Fig. 1, localities 1–2) and southern Vietnam (Fig. 1, locality 12) are distant from what appears to be the main range of the species, their status should be clarified.

The present report extends the known range of *S. buenloicus* from its type locality in Gia Lai Province of Vietnam approximately 235 km southwest to Phnom Namlyr Wildlife Sanctuary in Cambodia, which coincides with its recent discovery in the Dong Nai and Lam Dong provinces of southern Vietnam (Vassilieva *et al.*, 2016). Discovery of *S. buenloicus* can be also anticipated in north-eastern montane Cambodia (Virachey National Park). This is the first record of *S. buenloicus* outside Vietnam and constitutes the fifth species of *Sphenomorphus* documented in Cambodia. Our discovery highlights the current incompleteness of information on reptiles in the eastern plains of Cambodia. This area has close affinities to the Annamite Mountains where many new species and herpetofaunal records have recently been documented (Nazarov *et al.*, 2012; Hartmann *et al.*, 2013; Nguyen *et al.*, 2013; Poyarkov *et al.*, 2014, 2015a, 2015b; Rowley *et al.*, 2016).

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References

Bobrov, V.V. & Semenov, D.V. (2008) *Lizards of Vietnam*. Tovarishchestvo Nauchnikh Izdanii KMK, Russia [in Russian].

Darevsky, I.S. (1990) Notes on the reptiles (Squamata) of some offshore islands along the coast of Vietnam. In *Vertebrates in the Tropics (*eds G. Peters & Hutterer R.), pp 125–129. Proceedings of an International Symposium on Veterbate Biogeography and Systematics in the Tropics, Museum Alexander Koenig, Bonn, Germany.

Darevsky, I.S. & Nguyen V.S. (1983) New and little known lizard species from Vietnam. *Zoologichesky Zhurnal*, **62**, 1827–1837 [in Russian].

Datta-Roy, A., Das, I., Bauer, A.M., Tron, R.K.L. & Karanth, P. (2013) Lizard wears shades: a spectacled *Sphenomorphus* (Squamata: Scincidae), from the sacred forests of Mawphlang, Meghalaya, north-east India. *Zootaxa*, **3701**, 257–276.

Grismer, L.L. (2008) A new species of insular skink (genus *Sphenomorphus* Fitzinger 1843) from the Langkawi Archipelago, Kedah, West Malaysia with the first report of the herpetofauna of Pulau Singa Besar and an updated checklist of the herpetofauna of Pulau Langkawi. *Zootaxa*, **1691**, 53–66.

Grismer, L.L., Muin, M.A., Wood, P.L.JR, Anura, S. & Linkem, C.W. (2016) The transfer of two clades of Malaysian *Sphenomorphus* Fitzinger (Squamata: Scincidae) into the genus *Tytthoscincus* Linkem, Diesmos, & Brown and the description of a new Malaysian swamp-dwelling species. *Zootaxa*, **4092**, 231–242.

Grismer, L.L., Neang T., Chav T. & Grismer, J.L. (2008) Checklist of the amphibians and reptiles of the Cardamom region of southwestern Cambodia. *Cambodian Journal of Natural History*, **2008**, 12–28.

Hartmann, T., Geissler, P., Poyarkov, N.A., Ihlow, F., Galoyan, E.A., Rödder, D. & Böhme, W. (2013) A new species of the genus *Calotes* Cuvier, 1817 (Squamata: Agamidae) from southern Vietnam. *Zootaxa*, **3599**, 246–260.

Hartmann, T., Nguyen Q.T., Ohler, A., Hun C, Handschuh, M. & Böhme, W. (2010) Rediscovery of the rare Thai scincid lizard *Sphenomorphus lineopunctulatus* Taylor, 1962: new country records from Cambodia and Laos and a redescription. *Russian Journal of Herpetology*, **17**, 105–109.

Jestrzemski, D., Schütz, S., Nguyen Q.T. & Ziegler, T. (2013) A survey of amphibians and reptiles in Chu Mom Ray National Park, Vietnam, with implications for herpetofaunal conservation. *Asian Journal of Conservation Biology*, **2**, 88–110.

Lim, L.J. (1998) *The taxonomy of West Malaysian and Singapore Scincidae (Reptilia: Sauria)*. MSc thesis, National University of Singapore, Singapore.

Linkem, C.W., Diesmos, A.C. & Brown, R.M (2011) Molecular systematics of the Philippine forest skinks (Squamata: Scincidae: *Sphenomorphus*): testing morphological hypotheses of interspecific relationships. *Zoological Journal of the Linnean Society*, **163**, 1217–1243.

Nazarov, R., Poyarkov, N.A., Orlov, N.L., Phung T.M., Nguyen T.T., Hoang D.M. & Ziegler, T. (2012) Two new cryptic species of the *Cyrtodactylus irregularis* complex (Squamata: Gekkonidae) from southern Vietnam. *Zootaxa*, **3302**, 1–24.

Nguyen V.S., Ho T.C. & Nguyen Q.T. (2009) *Herpetofauna of Vietnam*. Edition Chimaira, Frankfurt, Germany.

Nguyen S.N., Le T-N.T., Tran T.A.D., Orlov, N.L., Lathrop, A., Macculloch, R.D., Le T-D.T., Jin J-D., Nguyen L.T., Nguyen T.T., Hoang D.D., Che J., Murphy, R.W. & Zhang Y-P. (2013) Phylogeny of the *Cyrtodactylus irregularis* species complex (Squamata: Gekkonidae) from Vietnam with the description of two new species. *Zootaxa*, **3737**, 399–414.

Nguyen Q.T., Schmitz, A., Nguyen T.T., Orlov, N.L., Böhme, W. & Ziegler, T. (2011) Review of the genus *Sphenomorphus* Fitzinger, 1843 (Squamata: Sauria: Scincidae) in Vietnam, with description of a new species from northern Vietnam and southern China and the first record of *Sphenomorphus mimicus* Taylor, 1962 from Vietnam. *Journal of Herpetology*, **45**, 145–154.

Poyarkov, N.A., Orlov, N.L., Moiseeva, A.V., Pawangkhanant, P., Ruangsuwan, T., Vassilieva, A.B., Galoyan, E.A., Nguyen T.T. & Gogoleva, S.S. (2015a) Sorting out moss frogs: mtDNA data on taxonomic diversity and phylogenetic relationships of the Indochinese species of the genus *Theloderma* (Anura, Rhacophoridae). *Russian Journal of Herpetology*, **22**, 241–280.

Poyarkov, N.A., Rowley, J.J.L., Gogoleva, S.S., Vassilieva, A.B., Galoyan, E.A. & Orlov, N.L. (2015b) A new species of *Leptolalax* (Anura: Megophryidae) from the western Langbian Plateau, southern Vietnam. *Zootaxa*, **3931**, 221–252.

Poyarkov, N.A., Vassilieva, A.B., Orlov, N.L., Galoyan, E.A., Tran T.A.D., Le D.T.T., Kretova, V.D. & Geissler, P. (2014) Taxonomy and distribution of narrow-mouth frogs of the genus *Microhyla* Tschudi, 1838 (Anura: Microhylidae) from Vietnam with descriptions of five new species. *Russian Journal of Herpetology*, **21**, 89–148.

Rowley, J.J.L., Tran D.T.A., Le D.T.T., Dau V.Q., Peloso, P.L.V., Nguyen T.Q., Hoang H.D., Nguyen T.T. & Ziegler, T. (2016) Five new, microendemic Asian leaf-litter frogs (*Leptolalax*) from the southern Annamite mountains, Vietnam. *Zootaxa*, **4085**, 63–102.

Stuart, B.L., Sok K. & Neang T. (2006) A collection of amphibians and reptiles from hilly eastern Cambodia. *The Raffles Bulletin of Zoology*, **54**, 129–155.

Taylor, E.H. (1963) The lizards of Thailand. *University of Kansas Science Bulletin*, **44**, 687–1077.

Uetz, P., Freed, P. & Hošek, J. (eds) (2016) *The Reptile Database*. Http://www.reptile-database.org/data/ [accessed 21 August 2016].

Vassilieva, A.B., Galoyan, E.A., Poyarkov, N.A. & Geissler, P. (2016) *A Photographic Field Guide to the Amphibians and Reptiles of the Lowland Monsoon Forests of Southern Vietnam*. Edition Chimaira, Frankfurt, Germany.

Ziegler, T., Ohler, A., Vu N.T., Le K.Q., Nguyen X.T., Dinh H.T. & Bui N.T. (2006) Review of the amphibian and reptile diversity of Phong Nha-Ke Bang National Park and adjacent areas, central Truong Son, Vietnam. In *Herpetologia Bonnensis* II (eds M. Vences, J. Koehler, T. Ziegler & Boehme W.), pp 247–262. Proceedings of the 13th Congress of the Societas of Europaea Herpetologica, Bonn, Germany.

Postpartum phytomedicine and its future in maternal healthcare in Prey Lang, Cambodia

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មូលន័យសង្ខេប

ប្រទេសកម្ពុជាបានកាត់បន្ថយនូវអត្រាស្លាប់របស់ម្តាយតាមរយៈការធ្វើទំនើបកម្មមណ្ឌលសុខភាព មន្ទីរពេទ្យបង្អែកនៅតាមខេត្ត និង ការហាមឃាត់ការនុវត្តន៍របស់ឆ្មបបុរាណ(TBA)។ ការហាមឃាត់នេះដោយសារតែគេពុំដែលបានស្គាល់នូវវប្បធម៌ និង ចំណេះដឹងក្នុងការប្រើប្រាស់រុក្ខជាតិរបស់ប្រជាជនក្នុងតំបន់នោះ។ ដោយសារតែការស្លាប់របស់ម្តាយក្រោយឆ្លងទន្លេរួចគឺជាបញ្ហាមួយធ្ងន់ធ្ងរខ្លាំងនៅកម្ពុជា ដូច្នេះការសិក្សានេះមានគោលបំណងចងក្រងឯកសារទាក់ទងនឹងចំណេះដឹង អំពីការប្រើប្រាស់រុក្ខជាតិបែបបុរាណសម្រាប់ការការពារ និង ព្យាបាលស្ត្រីក្រោយឆ្លងទន្លេរួច។ រុក្ខជាតិចំនួន៦៨ប្រភេទ ស្មើនឹង៣៣អំបូរ ត្រូវបានគេកត់ត្រា ក្នុងនោះមាន៖ អំបូរញRubiaceae(១០ប្រភេទ), អំបូរទេពទារូ Lauraceae(៥ប្រភេទ), អំបូរសណ្តែក Leguminosae(៥ប្រភេទ) និង អំបូរប៉ប្រើសSmilaceae(៣ប្រភេទ)។ ការប្រើប្រាស់ច្រើនបំផុតគឺទៅលើការធ្វើអោយហូបបាយបាន(៣៥%), សម្រួលសរសៃឈាម(២៥.៧%) និង សម្បូរទឹកដោះ(២២.៨%)។ ស្ត្រីជាម្តាយមកពីភូមិចំនួនពីរនៅភាគខាងជើងព្រៃឡង់បានស្គាល់រុក្ខជាតិ សម្រាប់ស្ត្រីឆ្លងទន្លេរួចពី៥០-៦០%ដែលប្រមូលដោយឆ្មបបុរាណនិងមិនមានភាពទាក់ទងគ្នាគួរអោយកត់សម្គាល់រវាងប្រភេទរុក្ខជាតិដែលប្រើប្រាស់ទៅនឹងអាយុរបស់ម្តាយឬជាមួយនឹងចំនួននៃការពរពោះនោះទេ។ តាមរយៈការអង្កេតនៅក្នុងភូមិពីរគឺភូមិចំពើន និង ភូមិស្តង់បានបង្ហាញថាមានការផ្លាស់ប្តូរពីការឆ្លងទន្លេនៅផ្ទះដោយឆ្មបបុរាណទៅឆ្លងទន្លេនៅមន្ទីរពេទ្យ។ មានភាពស្រដៀងគ្នា និង ខុសគ្នាមួយចំនួនទៅលើប្រភេទរុក្ខជាតិ និង វិធីប្រើប្រាស់សម្រាប់ស្ត្រីក្រោយឆ្លងទន្លេរួចនៅកម្ពុជា ធៀបទៅនឹងប្រទេសជិតខាងដូចជា ប្រទេសឡាវនិងប្រទេសថៃ។ យើងសូមស្នើអោយមានការបញ្ចូលនូវការប្រើប្រាស់ឱសថបុរាណដែលបានឆ្លងកាត់ទំនើបកម្មសម្រាប់ស្ត្រីក្រោយឆ្លងទន្លេរួចទៅក្នុងសេវាកម្មមាតុភាពដែលចាំបាច់ ព្រោះវាមិនត្រឹមតែរួមចំណែកក្នុងការការពារបេតិកភ័ណ្ឌជីវប្បធម៌បុណ្ណោះទេ តែវាក៏ជាសក្តានុពលនៃការស្រាវជ្រាវផ្នែកឱសថផងដែរ។

Abstract

Cambodia has reduced maternal mortality rates by modernizing provincial health centres and referral hospitals as well as by banning traditional birthing attendants (TBAs) from practicing. The implications this will have on ethnobotanical knowledge and the local culture are unknown. Because postpartum mortality is a dire reality in Cambodia, this study aimed to document knowledge on traditional phytomedicine for the prevention and treatment of postpartum compli-

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cations. Sixty-eight plant species belonging to 33 families were recorded, the most prevalent being Rubiaceae (*n*=10), Lauraceae (*n*=4), Leguminosae (*n*=4) and Smilaceae (*n*=3). The most common uses were appetite stimulation (34.2%), improving blood circulation (25.7%) and stimulating milk production (22.8%). Mothers from two villages in northern Prey Lang, Cambodia, recognized 50–60% of postpartum plants collected by TBAs and there was no significant correlation between plant recognition and the mother's age, nor with the number of pregnancies had. A shift from home births with TBAs towards hospital births in the villages of Chamraeun and Spong was observed. There are similarities and differences in the diversity of Cambodian postpartum plants and their uses compared to neighbouring Laos and Thailand. We suggest an integrative approach to maternity services is needed in which traditional medicine supplements modern postpartum healthcare, while preserving bio-cultural heritage and potential pharmacological discoveries.

Keywords

Ethnobotany, indigenous, Kuy, Kui, Kuoy, local ecological knowledge, midwifery, traditional ecological knowledge.

Introduction

Indigenous communities' knowledge and use of medicinal plants is increasingly vulnerable in developing nations, its threat having both cultural and pharmacological repercussions (Bodeker & Kronenberg, 2002; Shanley & Lutz, 2003; Bolson *et al.,* 2015). Factors including deforestation, rural exodus, and modernisation of health services could potentially influence the way developing societies relate to and use their surrounding environments. Estimates from 2005 reveal that 70–95% of people living in Asia, Latin America, and the Middle East use traditional medicine as their main form of health care (Rocha *et al.,* 2016).

High maternal mortality is of major health concern in most developing countries. In 2010, an estimated 287,000 deaths worldwide were due to avoidable maternal complications, and most occurred in countries with living standards at or below middle-class, making it vital to focus attention on prevention and treatment of ailments related to pregnancy in these areas (Say *et al.,* 2014). Estimates also suggest that half of maternal deaths occur during the postpartum period, the time immediately following birth and extending up to six weeks afterwards, when a mother's body returns to its non-pregnant state. Similar trends have been observed in Cambodia, where high fertility and high maternal mortality indicates that motherhood encompasses risks and challenges across the nation. The World Health Organization (WHO, 2013) estimated a maternal mortality rate (MMR) of 170 deaths per 100,000 births in Cambodia, a 15% decrease since 2009. While a promising reduction in a short time period, this remains far higher than MMRs in developing countries which average 12 deaths per 100,000 births (WHO, 2014). In Cambodia, fertility is currently observed at 3.3 children per woman in rural areas compared to 2.2 in urban areas and this contributes to a higher risk of maternal mortality in the countryside (Kalaichandran & Zakus, 2007; Liljestrand & Sambath, 2012).

The unregulated nature and varying quality of traditional birthing practices in Cambodia led to a ban on traditional birthing attendants (TBAs) in 2006 and setting of national standards for obligatory midwife certification programs (Ith *et al.,* 2012; Wang & Hong, 2015). This effectively increased facility deliveries by trained personnel by 78.6% from 2006 to 2011, whereas births by TBAs decreased by 81.5%, contributing to the reduction in MMR nationally (Ir *et al.,* 2015). What has been ignored under this development, however, is how healthcare modernisation may influence future traditional knowledge on medicinal plants when TBAs abandon their practices or when mothers lose interest and trust in their use. Though the efficacy and safety of traditional medicine poses a concern, the cultural value of traditional medicine and its potential to supplement modern practices remains relevant in developing countries such as Cambodia. The risk that valuable information about traditional medicinal plants may vanish is pertinent because many people live far from modern facilities and are often dependent upon traditional medicine (Bodeker & Kronenberg, 2002; Lundh, 2007; Ansari & Inamdar, 2010; Bolson *et al.,* 2015). Integration of traditional medicinal practices in modern times has been documented in Ghana, Nicaragua, and China, and these studies provide insights on how the same could be achieved in Cambodia (Carrie *et al.,* 2015; Chan *et al.,* 2015; Boateng *et al.,* 2016).

Cultural beliefs regarding health often guide indigenous peoples in their choices of plants to prevent and heal ailments. In many cultures around the world, notably in Central America and Asia, there reigns a theory of hot and cold internal balance in the body. Traditional healers prescribe plant medicines according to their balancing effect upon the body's thermal state (Fishman *et al.,* 1988; Nestler, 2002; de la Cruz *et al.,* 2014; García-Hernández, 2015; Teixidor-Toneu *et al.,* 2016). This practice is also prevalent amongst the Khmer and Kuy ethnic groups in Cambodia, who deem preg-

nancy as a "hot" state and postpartum as a "cool" state and target the latter with traditional medicines that have a warming effect (Tea, 2002; White, 2004). Another cultural aspect of health referenced by TBAs is the belief in "toas", a form of relapse caused by foods or activities deemed inappropriate, particularly after giving birth. This state manifests in many ways including diarrhoea, nausea, loss of appetite, and general weakness, yet has no English translation (White, 2002). Medical explanations for toas are disputed, some deeming it a culture-bound syndrome comprising a combination of psychiatric and somatic symptoms (Tea, 2010).

Literature is sparse on the traditional use of phytomedicine (i.e. herbal medicine) to prevent and treat postpartum complications in Cambodia. Only a handful of articles on the postpartum traditions of the Khmer and Kuy ethnic groups can be found, and documentation on specific plants used in this regard is lacking (Hoban, 2002; White, 2002, 2004). More in-depth information on plants used can be gathered from neighbouring countries, particularly Laos (Lundh, 2007; Lamxay *et al.,* 2011; de Boer *et al.,* 2011), where ecological and demographic conditions are in several ways similar to Cambodia. Prey Lang Wildlife Sanctuary covers 431,683 ha in the Stung Treng, Stung Treng, and Kratie provinces and protects Cambodia's largest remaining area of lowland evergreen forest (Souter *et al.,* 2016). Social development and resource extraction has been detrimental to cultural and biological conservation at the site, with increasing pressure from illegal logging, resin tapping, economic land concessions and agricultural land conversion (Strange *et al.,* 2007). Multi-genus botanical surveys on postpartum plants in Preah Vihear and Stung Treng, two provinces that stretch across the north of the wildlife sanctuary, have yet to be published (Koung, 2007). Lamxay *et al.* (2011) referred to a French *materia medica* study from 1930 in their comparison of postpartum species from Laos to Cambodian equivalents, but did not specify their regional origins. Of medicinal plants used by the Kuy, an ethnic group in Prey Lang, almost 30% are used to treat postpartum ailments (Turreira-Garcia, 2015), thus such knowledge is an important part of the Kuy ethnobotanical heritage.

This study aimed to document postpartum medicinal plants and address their relation to health and cultural preservation by answering the following questions: 1) what plants are used for postpartum ailments by women and TBAs in northern Prey Lang; and, 2) does the changing healthcare system affect women's knowledge and use of postpartum medicinal plants?

Methods

Fieldwork took place at four villages within and near the forests of Prey Lang from 23 April to 11 May, 2015 (Fig. 1). The order of remoteness and proximity to old growth forest of the study villages from least to greatest was: Chamraeun, Thmea, Phneak Roluek, and Spong. The populations of these villages are roughly 940 people in Chamraeun, 578 people in Phneak Roluek, 497 people in Spong, and 2,024 in Thmea (NCSNDD, 2010). Local residents practice subsistence farming and mainly obtain their income from cultivation of rice and other staple products as well as tapping resin. Most of the population is of Kuy descent (62%), either fully or with one Kuy parent.

Data collection was undertaken through interviews with mothers, focus group discussions with TBAs, interviews with personnel at a provincial health centre, and collection of voucher specimens of postpartum plants. In group and individual interviews, practices for harvesting and preparation of medicinal plants were explored. As the sensitive nature of the study warranted attention to participant willingness to collaborate, consideration for their privacy was of the utmost importance. All participants were informed of the objective of the study and agreed to share their knowledge. Respondent ages in the Chamraeun and Spong villages ranged from 19 to 80 years old and the mean age of respondents was 42 years (Appendix 1). Both the interviewer and translator were female.

Focus group discussions were held with three former TBAs in Chamraeun village and one former TBA in Spong village. In these villages, TBAs were asked to collect as many as five of the most common postpartum plant species used. These were then used in a knowledge pattern analysis whereby mothers were asked to state their ethnospecies name (common name) and describe their use. This allowed cross-checking of their knowledge with information provided by TBAs. Five plant species were collected from Chamraeun village (ampil, lermeet kerbal pous, ploosbart, protiel tlem kmov, and teab buy) and four from Spong village (ampil, kandangbay, potrea, and teab buy). Forty plant recognition interviews were undertaken with mothers (Chamraeun: n=22; Spong: n=18). Additionally, 47 women, including three former TBAs (Appendix 1), were interviewed about their birthing experiences and future preferences. Selection of women for interviews was random, the only criteria being that they had to have given birth at least once.

Free listings, whereby participants drew upon their memory of postpartum medicinal plants to create a list of useful species, were held in each village and plant collec-

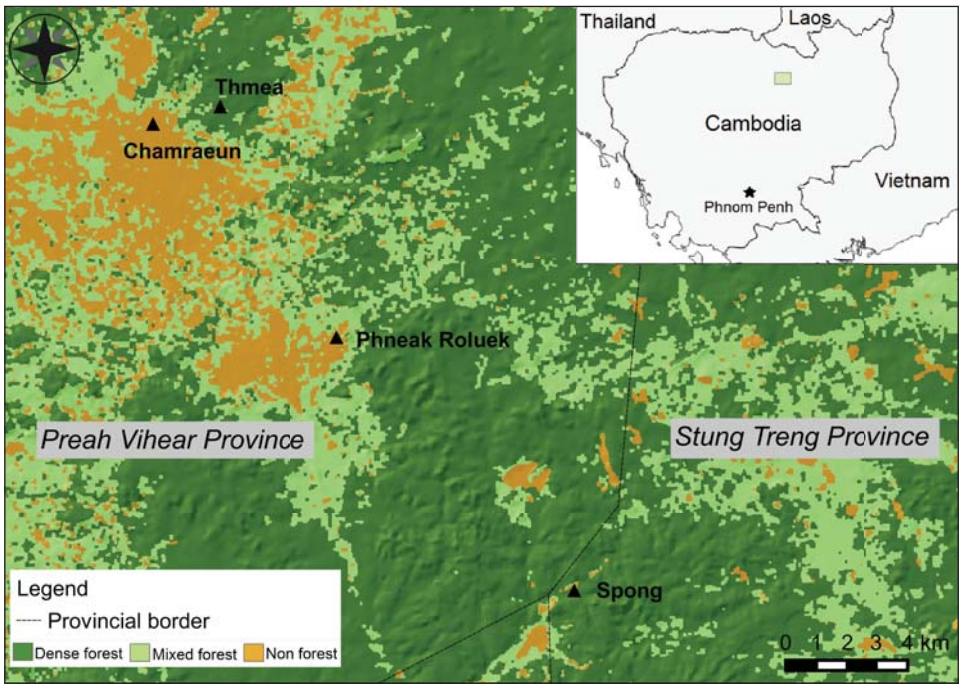

Fig. 1 Location of study sites in Prey Lang Wildlife Sanctuary (main map) and Cambodia (inset map). Created using forest cover (Open Development Cambodia, 2014) and natural earth data in QGIS.

tion started from villages into the surrounding vegetation. The collection from Chamreun was unfortunately lost in transportation. Several nights were also spent in the forest to obtain species in less accessible areas. The overall goal was to collect all plants mentioned during the free listings, and any other postpartum medicinal plants recognised in the field. Voucher specimens were collected and initially retained in the Forest and Wildlife Research Institute, Forestry Administration in Phnom Penh, Cambodia. These were later transferred to the Queen Sirikit Botanic Garden (QSBG) in Chiang Mai, Thailand for secondary inspection and identification. All permits required for the study were in accordance with the Nagoya Protocol on Access and Benefit Sharing.

Paired T-tests were undertaken using RStudio© (Version 0.99.441, 2015) to assess whether number of plants recognized by respondents differed between age groups or numbers of pregnancies carried to term by mothers.

Results

Postpartum phytomedicine in Prey Lang

Sixty-eight species used for the postpartum period were collected belonging to 33 families, with Rubiaceae (ten species), Lauraceae (four species), Leguminosae (four species), and Smilaceae (three species) being the most represented (Table 1). Preparation of these was primarily as an infusion in tea (61 species, 89.7%), and four plant species were also taken as a tincture in rice wine. Preparation practices for the remaining plant species were not specified. Villages differed on ethnospecies names, uses and/or application methods for seven plant species. Plants used for their postpartum effects in addition to supporting uterine (18 species, 26.5%) and general health (five species, 7.4%) included: orexigenic (i.e. stimulating appetite, 24 species, 35.3%); improving blood circulation including building "stronger" veins (17 species, 25%); galactagogue (i.e. stimulating milk production, 16 species, 23.5%); treating pain (i.e. body, joint, uterine) or a cold feeling in the uterus (nine species, 13.2%); uterotonic (i.e. inducing contraction of the uterus, in some cases reducing postpartum haemorrhage, seven species, 10.3%); and toas (three species, 4.4%). Three plant species (4.4%) were used for stopping blood loss, while two species were used to improve skin health and improve sleep/rest (2.9% for each category respectively). Lastly, one plant species was used to treat uterine prolapse, food poisoning, joint dislocation, boost the immune system, improve strength and flexibility, and provide refreshment (1.5% for each category respectively) (Fig. 2).

Table 1 Medicinal plants at Prey Lang with reported preparation methods and uses during the postpartum period. Voucher specimen numbers are given in parenthesis and voucher specimens are deposited in the Queen Sirikit Botanic Garden, Chiang Mai, Thailand. Village: PR – Phneak Roluek; SP – Spong; TH – Thmea. * Plant species used in knowledge pattern analysis.

Scientific name	Ethnospecies Name (Voucher No.)	Village	Postpartum Uses	Parts Used	Preparation
ACHARIACEAE					
Hydnocarpus anthelminthicus Pierre ex Laness.	Krorbao (130)	PR, SP	Galactagogue, uterine pain	Bark & wood	Infusion
ANNONACEAE					
Dasymaschalon macrocalyx Finet & Gagnep.	Cheungchab (40)	SP	Galactagogue, orexigenic, sleep/rest	Root	Infusion
Goniothalamus repevensis Pierre ex Fin. & Gagnep.	Krovan (136)	PR	Not specified	Not specified	Not specified
Goniothalamus tamirensis Pierre ex Finet & Gagnep.	Moom (160)	PR, SP	Orexigenic, uterotonic, blood circulation	Root	Infusion
APOCYNACEAE					
Holarrhena curtisii King & Gamble	Tekdors (302)	PR	Blood circulation, galactagogue	Bark & wood	Infusion with Ploosbart
ARECACEAE					
Calamus viminalis Willd.	Chongpdao (63)	SP, TH	Pain	Root	Infusion
ASPARAGACEAE					
Dracaena angustifolia (Medik.) Roxb.	Angraedaek (5)	PR, SP	Galactagogue, orexigenic, general health	Leaves & flower	Infusion
Peliosanthes teta Andrews	Tbaldaek (301)	SP	Uterotonic	Root	Infusion: roots of Angraedaek & Skun
ASPHODELACEAE					
Dianella ensifolia (L.) DC.	Kontoykror-per (114)	SP	Orexigenic, refreshment	Root & leaf base	Roast, then infusion
Markhamia stipulata (Wall.) Seem.	Dakpor (74)	PR	Uterine health	Not specified	Not specified
BORAGINACEAE					
Heliotropium indicum L.	Chompussek (61)	PR	Uterine health	Root	Infusion
CAPPARACEAE					
Capparis micracantha DC.	Kounh Chur beay dach (120)	PR	Not specified	Not specified	Not specified
CELASTRACEAE					
Euonymus cochinchinensis Pierre	Koomouy (115)	PR, SP	Galactagogue, orexigenic	Bark, root & wood	Infusion
Salacia chinensis L.	Rorveay (247)	PR, SP	Uterine prolapse	Wood & nodes	Infusion
Salacia cochinchinensis Lour.	Vor Kondabchongae (351)	PR	Not specified	Bark & wood	Infusion
CLUSIACEAE					
Garcinia merguensis Wight	Kres (126)	PR	Not specified	Bark	Not specified
Garcinia sp. 2	Yeam (381)	PR, SP	Blood circulation	Bark, root & wood	Infusion

Table 1 (Continued)

Scientific name	Ethnospecies Name (Voucher No.)	Village	Postpartum Uses	Parts Used	Preparation
CONNARACEAE					
Ellipanthus tomentosus Kurz	Kd Komprok (96)	PR, SP	Orexigenic	Root	Infusion with Reum
DILLENIACEAE					
Dillenia hookeri Pierre	Ploosbart* (187)	PR, TH	Galactagogue, general health, food poisoning	Root	Infusion
EBENACEAE					
Diospyros ehretioides Wall. ex G. Don	Mormeang (161)	PR	Blood circulation	Bark & root	Infusion
Diospyros sylvatica Roxb.	Khanhchas (98)	PR	Uterine health	Root	Infusion
Diospyros undulata Wall. ex G. Don	Chherplerng (44)	SP	1. Galactagogue; 2. Pain & cold in uterus	1. Root (best) or bark; 2. Bark & wood	
ERYTHROXYLACEAE					
Erythroxylum cambodianum Pierre	Chompussek (60)	PR, SP	Blood circulation, orexigenic	Root	Infusion
EUPHORBIACEAE					
Antidesma ghaesembilla Gaertn.	Dongkeabk-dam (82)	PR, SP	General health	Bark & wood	Infusion
Croton sp.	Montek (159)	PR	Toas	Root	Infusion
Suregada multiflora (A. Juss.) Baill.	Tronoumseik (321)	PR, SP	Galactagogue, orexigenic, blood circulation	Bark, root & wood	Infusion
LAMIACEAE					
Gmelina asiatica L.	Anhcharnh (7)	PR, SP	Joint dislocation	Root	Dry, then infusion
Vitex pinnata L.	Porpool (200)	PR, SP, TH	Galactagogue, orexigenic, general health	Bark & wood	Infusion
Vitex sp.	Protespray (223)	PR	Not specified	Not specified	Not specified
LAURACEAE					
Cinnamomum bejolghota (Buch-Ham.) Sweet	Sroumdav (293)	PR, TH	Blood circulation, uterine health	Root, bark & wood	Infusion
Cinnamomum polyadelphum (Lour.) Kosterm.	Slapok (267) Tepproo (303)	PR, SP, TH	Not specified, Pain & cold feeling in uterus, joint & body pain	Root	Infusion, infusion with bark & Chherplerng wood, or tincture
Cinnamomum sp.	Sromday (284)	PR	Not specified	Root & bark	Infusion
Ocotea lancifolia (Schott) Mez	Krolor (127)	PR	Galactagogue, orexigenic	Root	Infusion
LEGUMINOSAE					
Acacia sp.	Vor Torleng (376)	PR	Orexigenic	Bark & wood	Infusion or rice wine tincture
Tadehagi triquetrum (L.) H.Ohashi	Angkrorng (4)	PR	Joint or bone pain, orexigenic	Whole plant	Infusion

Table 1 (Continued)

Scientific name	Ethnospecies Name (Voucher No.)	Village	Postpartum Uses	Parts Used	Preparation
Uraria sp.	Chang Kesang Kreang (36)	PR	Blood circulation	Root & bark	Dry, then infusion
Xylia xylocarpa (Roxb.) Taub.	Chkrom (56)	SP, TH	Skin health	Root	Infusion
LYTHRACEAE					
Lagerstroemia speciosa (L.) Pers.	Kraol (123)	PR, SP, TH	Orexigenic, boost immune system, skin health	Bark	Infusion
MALVACEAE					
Colona auriculata (Desf.) Craib	Preal (208)	PR, SP	Uterotonic, uterine pain	Root	Infusion with Dakun root (*Tetracera loureiri*)
Waltheria indica L.	Preash Proa Veal (211)	TH	Uterine health	Root	Infusion
MELASTOMATACEAE					
Melastoma malabathricum L.	Baynhenh (20)	PR	Orexigenic	Root	Infusion
Melastoma saigonense (Kuntze) Merr.	Baynhenh (22)	SP	"Stronger" veins, galactagogue, orexigenic	Root	Infusion with root of male plant
Melastoma sanguineum Sims	Baynhenh (21)	PR, SP	"Stronger" veins, galactagogue, orexigenic	Root	Infusion with root of female plant
MORACEAE					
Ficus racemosa L.	Lovear (149)	PR	Galactagogue	Outer part of seed	Infusion
MYRTACEAE					
Syzygium zeylanicum (L.) DC.	Smarch (271)	PR, SP, TH	Not specified	Bark & wood	Infusion
OCHNACEAE					
Ochna integerrima (Lour.) Merr.	Angkea (3)	PR, SP	Blood circulation, orexigenic, uterotonic	Root, bark & wood	Infusion
PHYLLANTHACEAE					
Hymenocardia punctata Wall. ex Lindl.	Komkhneang (107)	PR, SP	1. Blood circulation; 2. Galactagogue, orexigenic, general health	1. Bark; 2. Root	1. Infusion or rice wine tincture; 2. Infusion
PINACEAE					
Pinus merkusii Jungh. & de Vriese	Srorl (286)	SP	Body pain	Root & bark	Infusion
RHAMNACEAE					
Ventilago cristata Pierre (unresolved name)	Vor Tonlueng (375)	SP	Blood circulation	Vine	Infusion
Ziziphus oenopolia (L.) Mill.	Vor Sangkher, also Vor Sangkhouch or Sangkher (367)	PR, SP, TH	Galactagogue, orexigenic, stop blood loss, strength & flexibility	Root & vine	Infusion with other plants (not specified)

Table 1 (Continued)

Scientific name	Ethnospecies Name (Voucher No.)	Village	Postpartum Uses	Parts Used	Preparation
RUBIACEAE					
Coptosapelta flavescens Korth.	Tonling (313)	PR	Blood circulation	Bark & wood	Infusion or rice wine tincture
Ixora nigricans R. Br. ex Wight & Arn.	Pkamuchol (185)	PR	Pain	Root	Infusion
Lasianthus hirsutus (Roxb.) Merr.	Skun (265)	PR, SP	Orexigenic, uterotonic	Root	Infusion with Tbaldaek & Angraedaek root
Mitragyna hirsuta Hav.	Ktom, Ktomtom (137)	PR	Not specified	Root	Infusion with Roleay
Mitragyna sp.	Kvav (142)	PR, SP	Blood circulation	Not specified	Not specified
Mitragyna speciosa (Korth.) Havil.	Ktumphnom (141)	PR	Not specified	Root & bark	Infusion
Nauclea orientalis (L.) L.	Kdol (97), Ktom Roleay (138), Roleay (223)	PR, SP, TH	Orexigenic, blood circulation, stop blood loss, uterotonic, uterine health	Root (or bark)	Infusion or rice wine tincture
Oxyceros horridus Lour.	Thnungkan-hchos (310)	PR	Not specified	Root	Infusion or rice wine tincture
Prismatomeris filamentosa Craib	Romdenh-meas (238)	PR, SP	Orexigenic, sleep/rest, general health	Root	Infusion with other plants (not specified)
Prismatomeris memecyloides Craib	Romdenh (237)	PR, SP	Stop blood loss	Root	Infusion
RUTACEAE					
Murraya siamensis Craib (unresolved name)	Brohoung-arkas (28)	PR, SP	Toas	Root	Infusion
SIMAROUBACEAE					
Brucea javanica (L.) Merr.	Bromatmunus (30)	PR, TH	Not specified	Root	Infusion
Eurycoma longifolia Jack	Angtongsor (6)	PR, SP	Uterotonic	Root	Infusion
SMILACACEAE					
Smilax lanceifolia Roxb.	Porpreus (201)	PR	Not specified	Root	Infusion
Smilax megacarpa A.DC.	Porpreus Vor Rombers (362)	PR, SP	Blood circulation, hip pain	Root	Infusion with Chongpdao root
Smilax sp.	Porpreus (203)	SP	Orexigenic, uterotonic	Root	Infusion with Moom root
VIOLACEAE					
Rinorea anguifera Kuntze (unresolved name)	Dom dek pro ma (78)	PR	Uterine health	Root	Infusion
VITACEAE					
Leea indica (Burm. f.) Merr.	Kandangbay***** (90)	SP	Galactagogue, orexigenic, toas	Root	Infusion

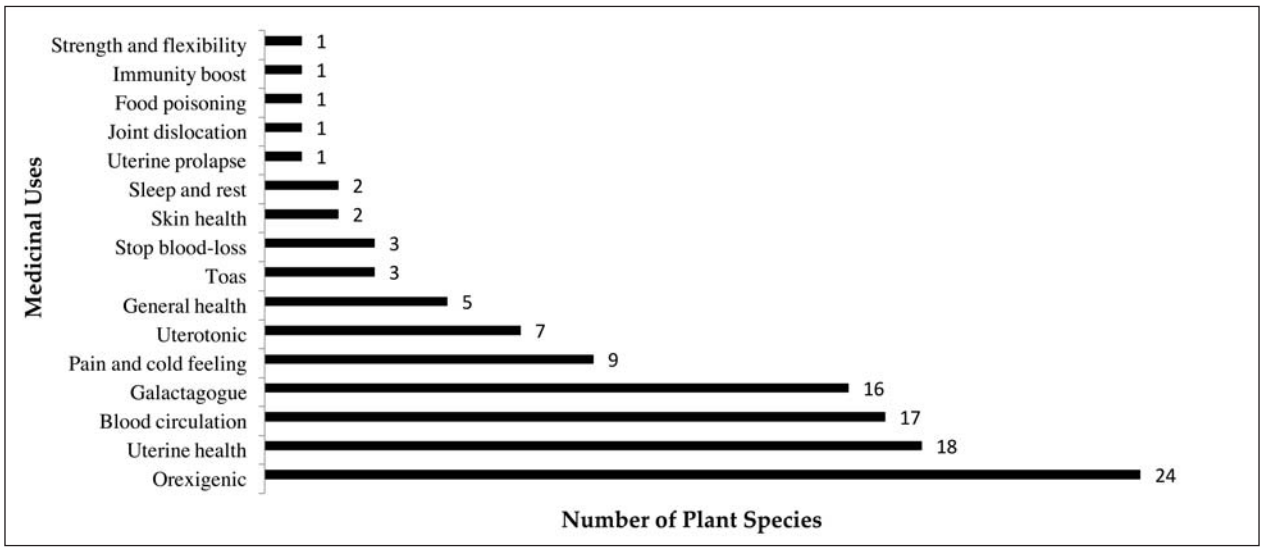

Fig. 2 Numbers of plant species employed for different postpartum uses at Prey Lang Wildlife Sanctuary. (Some species have multiple uses).

Toas and other postpartum ailments

An emic postpartum ailment that proved difficult to translate biomedically was related to consumption of "wrong" foods after delivery as well as resuming physical labour too quickly. There was little coherence in the recogition of different foods as "wrong" between respondents, yet the symptoms described were the same. These included "lock-jaw", which inhibits opening of the mouth to eat, and muscle tightness and pain over the whole body. Skin rash was also mentioned. Some respondents indicated that women should abstain from eating meat (specifically chicken and beef) and eggs after delivery. Others explained that prohibited foods vary according to personal preferences and tolerances. *Leea indica* was reported to alleviate skin rash, whereas *Croton* sp. and *Murraya siamensis* helped lock-jaw. *Neonauclea sessifolia* and *Prismatomeris memecycloides* were used for treating blood-loss after birth. Information about the cause of blood-loss (e.g., haemorrhage, mechanical tear) in women was not known or described in further detail. One respondent prescribed making a paste out of Teab buy seed (not collected, but used in the plant recognition analysis) and applying it directly to the breast to treat mastitis (inflammation of the breast tissue). Others reported experiencing mild pain, but regarded this sensitivity as normal in breastfeeding.

Women's knowledge and use of postpartum medicinal plants

Ethnospecies (local) names provided by TBAs were used as controls when investigating recognition of postpartum plants by mothers. Five plant species (ampil, lermeet kerbal pous, ploosbart, protiel tlem kmov, and teab buy) were used for recognition pattern analysis in Chamreun, whereas four (ampil, kandangbay, potrea, and teab buy) were used in Spong. Two plant species (ampil and teab buy) encountered in Chamraeun were also found and collected in Spong. These seven species were common according to the TBAs and there was agreement about their local names. Sixty percent of plant species (three out of five species) were identified correctly by the mothers in Chamraeun, whereas 50% (two out of four species) were correctly identified in Spong. No significant differences were found in terms of the number of plants recognised by different age groups (p=0.1547), or according to the number of pregnancies carried to term (p=0.2563).

Birthing experiences

No mothers reported miscarriages, yet four reported complications after birth, with one experiencing blood-loss and the others experiencing general weakness and mastitis. The remaining 43 respondents reported no complications in previous births.

Table 2 Frequencies of birthing experiences and future preferences among study respondents.

Group	Age	No of Respondents	No of Births	Previous Birthing Assistance			Future Birthing Preference			
				PHC/RH	TBA	Own	PHC/RH	TBA	Own	No comment
A	19–33	15	21	9, 62%	6, 38%		11, 73%	1, 7%	3, 20%	
B	34–38	10	32	1, 9%	9, 91%		6, 60%	4, 40%		
C	39–80	21	93		20, 97%	1, 3%	10, 48%	9, 43%	1, 5%	1, 5%

Mothers specified the number of successful births they had previously had, what kind of birthing assistance they had received (provincial health centre [PHC], referral hospital [RH], TBA, own family or other) and what their future preference would be if they could theoretically choose the next time they had a child (Table 2), as follows:

Group A: These mothers were younger (19–33 years of age, *n*=15) and had 1.3 successful births on average, 13 of which had occurred at a PHC or RH and eight with a TBA. Of the 15 respondents, 11 preferred PHC/RH delivery, three preferred to give birth at home with their family and one preferred to give birth with TBA assistance.

Group B: Mothers between 34 and 38 years of age constituted 21.3% of our sample (*n*=10/47) and had collectively experienced 32 births. Twenty-nine of these births had occurred with TBA assistance, while the remaining three took place at a PHC or RH. The ratio of preference for giving birth at a PHC/RH to TBA was 3:2. None preferred to give birth at home.

Group C: All respondents (*n*=21) 39 years of age and above had not given birth at a PHC or RH. All but one had received assistance from a TBA for their deliveries. The exception was the only study respondent who had given birth (on three occasions) with assistance of family members each time. She was also the only respondent in her age group who preferred to this manner of giving birth if she were to have another child. Ten of the remaining respondents preferred to give birth at a PHC/RH, whereas nine preferred to give birth with a TBA.

Discussion

Plants used for postpartum ailments

The plant species collected in this study and used for postpartum ailments by women and TBAs in northern Prey Lang represent a wide range of botanical families. These are compared below to those ecountered in studies of postpartum health in Laos (Lundh, 2007; de Boer & Lamxay, 2009) and Thailand (Panyaphu *et al.*, 2011; Srithi *et al.*, 2012) (Grape & Turreira-Garcia, 2015).

The genus *Psychotria* is common in Southeast Asia, and phytochemical analyses have shown that several species within the genus contain analgesic compounds, relieving afterpains and acting as a uterotonic, inducing contraction of the uterus and in some cases reducing postpartum haemorrhage (Lundh, 2007). The Mien (Yao), 15th–19th century migrants from middle and southern China who settled in Thailand and Laos, use *Psychotria* to aid the secretion of waste products from the vagina (Panyaphu *et al.*, 2011). In contrast, *Psychotria* species mentioned by Khmer and Kuy ethnic groups of Cambodia are described as having orexigenic (appetite stimulating) properties.

Species mentioned by Lundh (2007) such as *Croton roxburghii* had a galactagogue (stimulating milk production) and drying effect on the uterus, while the *Croton* sp. in our study was prescribed for toas related to improper food consumption. Differences in beliefs and biomedical causes and effects render categorisation of postpartum ailments and prescriptions ambiguous. For instance, the toas symptoms described as "lock-jaw" are strikingly similar to the warning signs of tetanus infection. Tetanus bacteria typically enter through a wound and as exposure of the compromised birth canal could provide such an entrance (Hassel, 2013), this warrants further investigation.

Three species of *Melastoma* (*M. malabathricum*, *M. saigonense*, and *M. sanguineum*) were reported to have orexigenic and galactagogue effects in our study, and also to improve blood circulation. Lundh (2007) referred to uterotonic properties of species in the same genus (*M. candidum*) that were verified on guinea pigs. *Melastoma candidum* was also described by Lao informants as having a contraceptive effect. Though no literature was found to this effect, stimulatation of contractions in the early stages of pregnancy could perhaps instigate abortion.

No *Melastoma* species where reported by Panyaphu *et al.* (2011), yet *M. malabathricum normale* is used by Hmong women in northern Thailand to treat dysmenorrhea, painful cramps and leucorrhea (in cases of abnormal vaginal discharge: Srithi *et al.,* 2012).

Ficus racemosa was prescribed by the women of Prey Lang as a galactagogue, and this may have some relation to Lundh's report of *F. hispida* treating an unspecified disease causing fatigue and weight loss. If a woman is malnourished, she is unlikely to produce enough milk, and it could be that *F. hispida* improves weight gain and the strength and ability to absorb nutrients. In contrast, the Mien of Thailand use *F. auriculata* to treat urinary infections (Panyaphu *et al.,* 2011). *Ochna* cf. *integerrima* was also noted by Lundh (2007) as having galactagogue properties and a drying effect on the uterus, whereas this reportedly had had orexigenic and uterotonic effects in our study. Inadequate food consumption can have marked effects on lactation, as demonstrated on rats (Teixeira *et al.,* 2002), and orexigenic and galactagogue properties may be related.

Ziziphus oenoplia has been reported to relieve pain in Laos and Thailand (Lundh, 2007; Panyaphu *et al.,* 2011), whereas in Prey Lang it is reportedly used as a galactagogue and orexigenic, and also for its ability to stem blood-loss and improve postpartum strength and flexibility. Two accounts also mention pain relief for *Smilax* sp. from Laos (Lundh, 2007), which accords with accounts for *S. megacarpa* in Cambodia, although the specimen we collected of *Smilax* sp. was reported to have orexigenic and uterotonic properties. The Mien in Thailand also use *S. lanceifolia* to treat peptic ulcers (Panyaphu *et al.,* 2011). *Leea indica* was reported by them to eliminate waste matter and improve blood flow (Panyaphu *et al.,* 2011), whereas Khmer and Kuy in Prey Lang reported galactagogue and orexigenic properties for the species, as well as effects upon toas ailments during the postpartum period. In Prey Lang, *Gmelina asiatica* is used in for supporting joint health. Another species in the same genus, *G. arborea*, is used to treat infected wounds and peptic ulcers by Mien in Thailand (Panyaphu *et al.,* 2011).

In related studies in Laos and Thailand (Lundh, 2007; de Boer & Lamxay, 2009; Panyaphu *et al.,* 2011; Srithi *et al.,* 2012), postpartum was unanimously the phase of pregnancy for which each ethnic group had the greatest knowledge and use of medicinal plants. Despite differences in specific uses, our study indicates that the communities of Prey Lang share this tendency. While herbal steam baths seems to be the most prevalent method of plant preparation elsewhere, Khmer and Kuy women in Prey Lang almost exclusively administer these as an infusion in tea.

Modernisation and its effects upon traditional knowledge

Traditional phytomedicine has been widely used by indigenous cultures long before the advent of modern medicine (Shanley & Lutz, 2003; Srithi *et al.,* 2009). However, modernisation has eroded traditional ecological knowledge worldwide, raising concerns for its continued existence (Gómez-Baggethun *et al.,* 2013). Given the short study period, the large number and range of species encountered in this study indicates the importance of Khmer and Kuy knowledge of postpartum plants at Prey Lang. Rapidly changing conditions such as forest degradation and agricultural land conversion will likely change the way people interact with their surrounding environments. The national ban on TBAs in 2006 and continued modernisation of healthcare services could also diminish traditional knowledge and use of phytomedicine in future. In this context, in serving as a reference point for future comparisons, this study may facilitate understanding of such effects.

Despite the contested efficacy of traditional medicine, botanical remedies are relevant due to their cultural importance, affordability and inherent potential for future discovery of new medicines (Laval *et al.,* 2011; de Boer & Cotingting, 2014). The many generations worth of traditional phytomedicinal knowledge at Prey Lang therefore has intrinsic value and ought to be documented given the potential for its disappearance in future. Integration of such knowledge with modern science may also be an efficient way to retain and honour community traditions. The forests of Prey Lang consequenty warrant further ethnobotanical research. Further pharmacological studies on the beneficial and adverse effects of postpartum plants at Prey Lang should attempt to identify the genera and species with the greatest efficacy and be integrated into modern healthcare to realise their benefits in reducing maternal mortality. Efficient integration of traditional medicine ought to encompass regulation, comprehensive educational campaigns, and capacity building. This would honour, and perhaps strengthen, cultural values were traditional medicine to compliment modern medicine in a holistic and individualized prevention and treatment regime (Bodeker & Kronenberg, 2002).

The present study merely touches the surface of what remains to be learned about traditional phytomedical methods of treating and preventing ailments after childbirth. Further ethnobotanical investigations will likely reveal parallels in Kuy culture in Laos and Thailand and

phytochemical analysis may verify reported applications of plants with their true biophysical effects. Given their botanical diversity, the forests of Prey Lang present a metaphorical, and at times literal, lifeline for the people of Cambodia. Further study and use of medicinal plants at Prey Lang may be key to continued conservation of this lowland evergreen forest and ensuring sustained benefits to local people. Whether the union of traditional and modern medicine will be adopted to help reduce maternal mortality is something coming years of developing community involvement and healthcare modernization will likely reveal.

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References

Ansari, J.A., & Inamdar, N.N. (2010) The promise of traditional medicines. *International Journal of Pharmacology*, **6**, 808–812.

Boateng, M.A., Danso-Appiah, A., Turkson, B.K. & Tersbøl, B.P. (2016) Integrating biomedical and herbal medicine in Ghana – experiences from the Kumasi South Hospital: a qualitative study. *BMC Complementary and Alternative Medicine*, **16**, 189.

Carrie, H., Mackey, T.K. & Laird, S.N. (2015) Integrating traditional indigenous medicine and western biomedicine into health systems: a review of Nicaraguan health policies and miskitu health services. *International Journal for Equity in Health*, **14**, 129.

Chan K., Hu X.Y., Razmovski-Naumovski, V. & Robinson, N. (2015) Challenges and opportunities of integrating traditional Chinese medicine into mainstream medicine: a review of the current situation. *European Journal of Integrative Medicine*, **7**, 67–75.

NCSNDD (2010) *Commune Database Online.* Http://db.ncdd.gov.kh/cdbonline/home/index.castle [accessed 21 September 2016].

de Boer, H.J, Lamxay, V. & Björk, L. (2011) Steam sauna and mother roasting in Lao PDR: practices and chemical constituents of essential oils of plant species used in postpartum recovery. *BMC Complementary and Alternative Medicine*, **11**, 128.

de Boer, H.J. & Cotingting, C. (2014) Medicinal plants for women's healthcare in Southeast Asia: a meta-analysis of their traditional use, chemical constituents, and pharmacology. *Journal of Ethnopharmacology*, **151**, 747–767.

de la Cruz, M.G., Malpartida, S.B., Santiago, H.B., Jullian, V., & Bourdy, G. (2014) Hot and cold: medicinal plant uses in Quechua speaking communities in the High Andes (Callejón de Huaylas, Ancash, Perú). *Journal of Ethnopharmacology*, **155**, 1093–1117.

Fishman, C., Evans, R. & Jenks, E. (1988) Warm bodies, cool milk: conflicts in post partum food choice for Indochinese women in California. *Social Science & Medicine*, **26**, 1125–1132.

García-Hernández, K.Y., Vibrans, H., Rivas-Guevara, M. & Aguilar-Contreras, A. (2015). This plant treats that illness? The hot–cold system and therapeutic procedures mediate medicinal plant use in San Miguel Tulancingo, Oaxaca, Mexico. *Journal of Ethnopharmacology*, **163**, 12–30.

Gómez-Baggethun, E., Corbera, E. & Reyes-García, V. (2013) Traditional ecological knowledge and global environmental change: research findings and policy implications. *Ecology and Society*, **18**, 72.

Grape, V. & Turreira-Garcia, N. (2015) *Voucher specimens of post-partum medicinal plants, version 1*. Unpublished catalogue, University of Copenhagen, Denmark.

Hassel, B. (2013) Tetanus: pathophysiology, treatment, and the possibility of using botulinum toxin against tetanus-induced rigidity and spasms. *Toxins*, **5**, 73–83.

Hoban, E. (2002) *We're safe and happy already: traditional birth attendants and safe motherhood in a Cambodian rural commune*. PhD thesis, University of Melbourne, Australia.

Ir, P., Korachais, C., Chheng K., Horemans, D., Van Damme, W. & Meessen, B. (2015) Boosting facility deliveries with results-based financing: a mixed-methods evaluation of the government midwifery incentive scheme in Cambodia. *BMC Pregnancy & Childbirth*, **15**, 170–185.

Ith P., Dawson, A. & Homer, C. (2012) Quality of maternity care practices of skilled birth attendants in Cambodia. *International Journal of Evidence-Based Healthcare*, **10**, 60–67.

Kalaichandran, A. & Zakus, D. (2007) The obstetric pathology of poverty: maternal mortality in Kep Province, Cambodia. *World Health & Population*, **9**, 38–47.

Koung L. (2007) *Postpartum practices among Cambodian mothers in Preah Vihear Province: a qualitative study of beliefs and practices*. MA thesis, Mahidol University, Thailand.

Lamxay, V., de Boer, H.J. & Björk, L. (2011) Traditions and plant use during pregnancy, childbirth and postpartum recovery by the Kry ethnic group in Lao PDR. *Journal of Ethnobiology and Ethnomedicine*, **7**, 14.

Laval, P., Rakotoarison, H., Savajol, N., & Vanny T. (2011). The Contribution of wild medicinal plants towards poverty alleviation and health improvements: a case study in two villages in Mondulkiri Province, Cambodia. *Cambodian Journal of Natural History*, **2011**, 29–39.

Liljestrand, J. & Sambath, M.R. (2012) Socio-economic improvements and health system strengthening of maternity care are contributing to maternal mortality reduction in Cambodia. *Reproductive Health Matters*, **20**, 62–72.

Lundh, E.C.S. (2007) *Plant use in ante- and postpartum health care in Lao PDR*. MSc thesis, Uppsala University, Sweden.

Menaut, B. (1930) *Matière Médicale Cambodgienne*. Imprimerie d'Extrême-Orient, Hanoi, Vietnam.

Nestler, G. (2002) Traditional chinese medicine. *Medical Clinics of North America*., **86**, 63–73.

Panyaphu, K., Van On T., Sirisa-ard, P., Srisa-nga, P., ChansaKaow, S. & Nathakarnkitkul, S. (2011) Medicinal plants of the Mien (Yao) in Northern Thailand and their potential value in the primary healthcare of postpartum women. *Journal of Ethnopharmacology*, **135**, 226–237.

Riggs, E.M. (2005) Field-based education and indigenous knowledge: essential components of geoscience education for native American communities. *Science Education*, **89**, 296–313.

Say, L., Chou D., Gemmill, A., Tunçalp, Ö., Moller, A., Daniels, J., Gülmezoglu, A.M., Temmerman, M. & Alkema, L. (2014) Global causes of maternal death: a WHO systematic analysis. *The Lancet Global Health*, **2**, 323–333.

Shanley, P. & Luz, L. (2003) The impacts of forest degradation on medicinal plant use and implications for health care in eastern Amazonia. *BioScience*, **53**, 573.

Souter, N.J., Simpson, V., Mould, A., Eames, J.C., Gray, T.N.E, Sinclair, R., Farrell, T., Jurgens, J.A. & Billingsley, A. (2016) Will the recent changes in protected area management and the creation of five new protected areas improve biodiversity conservation in Cambodia? *Cambodian Journal of Natural* History, **2016**, 1–5.

Srithi, K., Balslev, H., Wangpakapattanawong, P., Srisanga, P. & Trisonthi, C. (2009) Medicinal plant knowledge and its erosion among the Mien (Yao) in northern Thailand. *Journal of ethnopharmacology*, **123**, 335–342.

Strange, N., Theilade, I., Thea S., Sloth, A. & Helles, F. (2007) Integration of species persistence, costs and conflicts: an evaluation of tree conservation strategies in Cambodia. *Biological Conservation*, **137**, 223–236.

Tea J. (2010) *Cambodian Perinatal Culture-bound Syndromes: Providing Care to Women with Toas*. Https://ethnomed.org/clinical/pediatrics/cambodian-perinatal-culture-bound-syndromes-providing-care-to-cambodian-women-with-toas [accessed 20 September 2016].

Teixeira, C.V., Passos, M.C.F., da Fonte Ramos, C., Dutra, S. C.P. & de Moura, E.G. (2002) Leptin serum concentration, food intake and body weight in rats whose mothers were exposed to malnutrition during lactation. *The Journal of Nutritional Biochemistry*, **13**, 493–498.

Teixidor-Toneu, I., Martin, G.J., Ouhammou, A., Puri, R.K. & Hawkins, J. A. (2016) An ethnomedicinal survey of a Tashelhit-speaking community in the High Atlas, Morocco. *Journal of Ethnopharmacology*, **188**, 96–110.

Turreira-Garcia, N. (2015) *Voucher specimens of plants used by the Kuy ethnic group, version* 1. Unpublished catalogue, University of Copenhagen, Denmark.

Wang W. & Hong R. (2015) Levels and determinants of continuum of care for maternal and newborn health in Cambodia– evidence from a population-based survey. *BMC Pregnancy & Childbirth*, **15**, 1–9.

White, P.M. (2002) Crossing the river: Khmer women's perceptions of pregnancy and postpartum. *Journal of Midwifery & Women's Health*, **47**, 239–246.

White, P.M. (2004) Heat, balance, humors, and ghosts: postpartum in Cambodia. *Health Care for Women International*, **25**, 179–194.

WHO (2013) *Cambodia WHO Statistical Profile*. Http://www.who.int/gho/countries/khm.pdf [accessed 20 May 2015].

WHO (2014) *Trends in Maternal Mortality: 1990 to 2013, Estimates by WHO, UNICEF, UNFPA, the World Bank and the United Nations Population Division*. World Health Organization, Geneva, Switzerland.

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Appendix 1 Summary of study respondents

Village: CH – Chamraeun; SP – Spong. Job: F – Farmer; H – Healthcare; L – Logger; T – Resin tapper; S – Shop keeper. Income: Ag – Agricultural work; C – Corn; Cm – Child-minding; Ff – Food collection in forest; Lo – Logging; M – Meatballs; P – Potatoes; Re – Resin; Ri – Rice; Se – Sesame; Ss – Small shop; V – Vegetables; Wh – Wheat; Wi – Wine. [1]CAD – Complications after delivery. [2]TPT – Total pregnancies carried to term.

#	Village	Age	Ethnicity	Job	Income	Birthing Experience					Birthing Preference	
						CAD[1]	TPT[2]	Own	TBA	PHC	Choice	Reason, Comments
1	CH	58	Khmer	F	Ri		6		6		TBA	Familiar (former TBA)
2	CH	33	Kuy	F	Re		2		2		PHC	Easier than at home
3	CH	47	Kuy	F	Ri, P		4		4		TBA	Easier, hospital far away
4	CH	64	Kuy	F	Ri, Ss		2		2		TBA	No comment
5	CH	44	Kuy	F	Ri		5		5		PHC	Effective medicine
6	CH	58	Kuy	F	Ri, P, M, Wi		3	3			Own	Don't trust strangers at hospital (former TBA)
7	CH	80	Kuy	F	Ri		3		3		PHC	Reliable facilities
8	CH	57	Khmer	S	Ss	1	4		4		PHC	TBAs illegal
9	CH	55	Khmer	F	P		3		3		TBA	Easier, close to home
10	CH	23	Kuy	F	Ri, P		1			1	PHC	Easier, TBAs not educated
11	CH	35	Kuy	F	Ri		4		3	1	TBA	No comment
12	CH	74	Half	F	Ri		4		4		PHC	Better facilities
13	CH	19	Khmer	F	Ri		1			1	PHC	Safer
14	CH	52	Kuy	F	Ag		5		5		TBA	TBA experienced
15	CH	30	Kuy	F	Ri, V		1		1	1	PHC	Safer
16	CH	20	Kuy	F	Ri		1		1		PHC	Safer, many nurses
17	CH	27	Kuy	F	Ri, C, Wh		1			1	PHC	Safer
18	CH	42	Kuy	F	Ri		3		3		TBA	Easier, close to home
19	CH	21	Khmer	L	Lo		1			1	PHC	Better facilities, trustworthy
20	CH	60	Kuy	F	Ri, P		2		2		PHC	Doctor more qualified for complications
21	CH	67	Kuy	F	Ff		9		9		TBA	Easier, but TBAs illegal (former TBA)
22	CH	33	Kuy	F	P, Se		1			1	PHC	Safer, children healthier
23	CH	24	Khmer	F	Ri		2		1	1	Own	Hospital & TBAs both good
24	CH	20	Khmer	F	Ri		2			2	Own	Unsure
25	CH	25	Khmer	F	Ri		2		1	1	PHC	Safer, continual care
26	CH	35	Kuy	F	Ri		3		3		PHC	Safer
27	CH	25	Khmer	F	Ri		1		1		PHC	Safer
28	CH	35	Khmer	F	Ri		2		2		TBA	Prefers Khmer medicine
29	SP	55	Half	T	Re		7		7		PHC	Safer
30	SP	62	Kuy	F	Ss		5		5		PHC	Safer, doctors work together, TBAs work alone
31	SP	30	Half	T	Re		2			2	TBA	Easier, hospital far away

Appendix 1 (Continued)

#	Village	Age	Ethnicity	Job	Income	Birthing Experience					Birthing Preference	
						CAD[1]	TPT[2]	Own	TBA	PHC	Choice	Reason, Comments
32	SP	38	Khmer	T	Re		3		2	1	PHC	Safer, more doctors and effective medecine
33	SP	40	Khmer	F	Ri		6		6		PHC	Safer if complications
34	SP	36	Half	T	Re		3		3		TBA	Hospital too far
35	SP	50	Khmer	F	Ri	1	3		3		PHC	Safer
36	SP	21	Khmer	F	Ri, Re		1		1		Own	No comment
37	SP	49	Kuy	T	Re	1	5		5		PHC	No comment
38	SP	38	Kuy	F	Ri, Re		4		4		PHC	Safer, but far away
39	SP	38	Khmer	F	Ss, Re		2		2		PHC	Safer, especially in wet season, but not accessible
40	SP	38	Kuy	F	Ri, Re		4		4		TBA	Easier, nice to share knowledge
41	SP	45	Kuy	F	Ri, Re		5		5		TBA	Familiar, have good experience with TBAs
42	SP	37	Khmer	F	Ri		4		4		PHC	Safer
43	SP	50	Khmer	F	Ri, Re	1	5		5		TBA	Prefers Khmer medicine to pills
44	SP	35	Kuy	F	Ri, Re		3		2	1	PHC	Safer, if complications
45	SP	20	Khmer	F	Ri		1			1	PHC	No comment
46	SP	68	Kuy	F	Ri		4		4			No comment
47	SP	58	Khmer	H, S	Cm, Ss		6		6		PHC	TBA, Went to midwifery school, >100 births assisted, 14 years of practice

Recent Master's Theses

This section presents the abstracts of research theses produced by Royal University of Phnom Penh graduates recently awarded the degree of Masters of Science in Biodiversity Conservation. The abstracts have been edited for English.

Persistence of the Critically Endangered Bengal florican *Houbaropsis bengalensis* in a modern agricultural system, Cambodia

SON Virak

មូលន័យសង្ខេប

សត្វឪ្យឹប (*Houbaropsis begalensis)* ជាប្រភេទសត្វមានទីជម្រកនៅវាលស្មៅដ៏កម្រនៅក្នុងប្រទេសកម្ពុជា ហើយត្រូវបានដាក់បញ្ចូលជាប្រភេទសត្វទទួលរងការគំរាមកំហែងធ្ងន់ធ្ងរ និង ឈានទៅរកការផុតពូជ ដោយសារការបាត់បង់ទីជម្រក និង ចំនួនរបស់វាបានថយចុះយ៉ាងឆាប់រហ័ស។ ២ភាគ៣នៃប៉ុពុយឡាស្សុងលើពិភពលោកត្រូវបានប្រទះឃើញនៅលើវាលស្មៅ និង វាលស្រែប្រាំងក្នុងខេត្តកំពង់ធំ។ ដើម្បីធ្វើការអភិរក្សទៅលើសត្វប្រភេទនេះឲ្យមានប្រសិទ្ធភាព យើងត្រូវយល់ដឹងពីឥទ្ធិពលនៃការរំខានដែលកើតមានទៅលើវា។ ការសិក្សារបស់ខ្ញុំគឺបានស្វែងយល់ពីកត្តាទាំងនោះ ដែលអាចជះឥទ្ធិពលទៅលើការរស់នៅរបស់វានៅក្នុងខេត្ត ហើយបានធ្វើឡើងក្នុងកំឡុងរដូវប្រាំងនាឆ្នាំ២០១៥។

មានកត្តារំខានបួនយ៉ាង (មនុស្ស ម៉ូតូ គោយន្ត និង សត្វពាហនៈ) ត្រូវបានកត់បរិមាណនៅតាមជម្រកផ្សេងៗគ្នា ក្នុងទីតាំងសិក្សាទាំង ៦កន្លែងនៅក្នុងខេត្ត ស្ទោងជីក្រែង ចុងដូង គ្រោះក្រោម គោកព្រៃ និង តំបន់សានគរ។ កម្រិតនៃការរំខានខុសគ្នារវាងកត្តា និង ទីតាំង ប៉ុន្តែជាទូទៅជម្រកជាវាលស្រែទទួលការរំខានខ្លាំងជាងគេបំផុតដោយសត្វពាហនៈ និង មនុស្ស ចំណែកឯជម្រកជាព្រៃគម្លោតត្រូវបានរំខានខ្លាំងដោយមនុស្ស និង ម៉ូតូ។ ទាំងនេះមិនមែនជាកត្តាតែមួយគត់ដែលរំខានដល់ប៉ុពុយឡាស្សុងវាទេ តែកត្តានានាភាពនៃចំណីអាហាររវាងទីតាំង និង ជម្រកគឺពិតជាមានឥទ្ធិពលទៅលើការស៊ូទ្រាំរស់របស់ពួកវា។ ទោះជាយ៉ាងណាយើងឃើញមានប៉ុពុយឡាស្សុងសត្វឪ្យឹបស៊ូទ្រាំរស់នៅក្នុងវាស្រែប្រាំង ដែលប្រមូលផលមុននៅក្នុងឆ្នាំ ហើយប្រហែលជាមានការពិបាករស់ខ្លាំងក្នុងតំបន់ដែលការប្រមូលផលក្រោយ។ ខ្ញុំសរុបសេចក្តីដោយស្នើឲ្យមានការសិក្សាបន្ថែមពីប្រភពចំណីរបស់វា និង សកម្មភាពរបស់មនុស្សនៅតាមតំបន់ដែលមានសត្វឪ្យឹបរស់នៅ។

Abstract

The Bengal florican *Houbaropsis begalensis* is the rarest grassland bird species in Cambodia and listed as Critically Endangered by the IUCN due to its small and rapidly declining population. Two-thirds of the global species population occurs in grasslands and dry season rice fields in Kampong Thom Province. As effective conservation of Bengal florican requires understanding of the effects of disturbance, my study explored how these factors may affect survival of the species in the province and was undertaken during the 2015 dry season.

Four disturbance factors (people, motorbikes, motorized ploughs, and cattle) were quantified in different habitats at six study sites within the province: Stoung-Chikreang, Baray, Chong Doung, Kros Krom, Kouk Presh, and San Kor. Levels of disturbance differed between factors and sites, but overall, rice field habitats were most disturbed by cattle and people, whereas scrubland habitats were most disturbed by people and motorbike traffic. These are unlikely to be only factors disturbing local populations of Bengal florican however, and variation in food availability between sites and habitats undoubtedly also influences their persistence. Nonetheless, populations of the species persisted in dry season rice fields that were harvested early in the year and appeared to suffer in areas where these were harvested later. I conclude by recommending further studies on food availability and human activity at sites where Bengal florican occurs within the province.

Citation: Son V. (2016) Persistence of the Critically Endangered Bengal Florican *Houbaropsis bengalensis* in a modern agricultural system, Cambodia. *Cambodian Journal of Natural History*, **2016**, 134.

The feeding biology of *Channa striata* and *Clarias batrachus* in community fish refuges and Tonle Sap Lake, Pursat Province

TAM Sreykol

មូលន័យសង្ខេប

សមត្ថភាពក្នុងការចាប់សត្វរំពារបស់ត្រីខុសគ្នារវាងប្រភេទនីមួយៗ ហើយការយល់ដឹងពីប្រភេទសត្វរំពាដែលត្រូវបានស៊ីគឺជាទិដ្ឋភាពសំខាន់នៃអាកប្បកិរិយារបស់ប្រភេទត្រី។ កន្លែងរកស៊ីចំណីរបស់ត្រីទឹកសាបគឺកម្មវត្ថុស្រាវជ្រាវមិនដាច់របស់វិស័យគ្រប់គ្រងជលផល។ ការសិក្សារបស់ខ្ញុំគឺស្រាវជ្រាវពីការស៊ីចំណី និង របបអាហាររបស់ត្រីរ៉ស់*Channa striata* និង ត្រីអណ្តែង*Clarias batrachus* នៅសហគមន៍ស្រះជម្រកត្រីពីរកន្លែង(បឹងរំលិច និង បឹងត្រាំសេះ) ក្នុងស្រុកបាកាន ខេត្តពោធិ៍សាត់ និង ភូមិបណ្តែតទឹកលើបឹងទន្លេសាបមួយកន្លែង (ភូមិកំពង់លួង) ក្នុងស្រុកក្រគរ ពីខែកុម្ភៈ ដល់ខែឧសភា ឆ្នាំ២០១៥។

ក្នុងការសិក្សានេះមានត្រីរ៉ស់២៤០ក្បាល និង ត្រីអណ្តែង៦០ក្បាល ត្រូវបានប្រមូលពីទីតាំងទាំងបី (បឹងរំលិច១៥៥ក្បាល បឹងត្រាសេះ ១២១ក្បាល និង ភូមិកំពង់លួង១២៤ក្បាល)។ ការវិភាគសមាសធាតុក្នុងក្រពះត្រីនៅមន្ទីរពិសោធន៍បានរកឃើញអាហារ ៣៥ប្រភេទ ត្រីទាំងពីរប្រភេទនេះមានប្រវែង ទម្ងន់ខ្លួន និង ទម្ងន់ក្រពះប្រហាក់ប្រហែលគ្នា។ ត្រីរ៉ស់ស៊ីអាហារច្រើនប្រភេទក្នុងខែកុម្ភៈ ដែលមានចំនួន៣២ប្រភេទ ប្រភេទអាហារដែលច្រើនជាងគេគឺ បំណែកត្រី បំណែករុក្ខជាតិ អេប៉ុង(*Spongilla*) ប្លង់តុង និង ប្រូតូសូអ៊ែ។ ត្រីអណ្តែងស៊ីអាហារ២២ប្រភេទ ប្រភេទអាហារដែលច្រើនជាងគេគឺ បំណែកត្រី ប្រូតូសូអ៊ែ បំណែករុក្ខជាតិ ប្លង់តុង អេប៉ុង(*Spongilla*) កំពឹសទឹកសាបនិងកញ្ជ្រោទឹក។ សមាសភាគផ្សំនៃអាហារមាននានាភាពខ្ពស់នៅបឹងរំលិចគឺ ២៨ប្រភេទ ត្រូវបានកត់ត្រា ១៩ប្រភេទស៊ីដោយត្រីរ៉ស់ និង ១៥ប្រភេទដោយត្រីអណ្តែង។

Abstract

The ability of fish to catch prey differs between species and understanding of the types of prey consumed is an important aspect of species behaviour. The feeding habits of fresh water fish are consequently subject to continuous research in the fisheries management sector. My study investigated the feeding biology and diet of the freshwater fish *Channa striata* and *Clarias batrachus* at two community fish refuges (Boeng Romlech and Bong Tramcess) in Bakan district of Pursat Province and one site (Kom Ponglong flooding village) in Krakor district on the Tonle Sap Lake from February to June 2015.

Over the course of the study, 240 *C. striata* and 160 *C. batrachus* were collected at the three sites (155 fish at Boeng Romlech, 121 at Bong Tramcess, and 124 at Kom Ponglong). Laboratory analysis of stomach contents revealed 35 types of food from this sample and the two species were similar in terms of length, weight, and stomach weight. *Channa striata* consumed the most types of food in February and was found to consume 32 types of food in total, the most common items being fish-parts, plant-parts, *Spongilla* sponges, rotifers, and protozoa. *Clarias batrachus* cosumed 22 types of food, the most common items being fish-parts, protozoa, plant-parts, rotifers, *Spongilla* sponges, fresh water shrimps, and water beetles. Diet composition was most diverse at Boeng Romlech with 28 types of food documented, 19 of which were consumed by *C. striata* and 15 by *C. batrachus*.

Citation: Tam S. (2016) The feeding biology of *Channa striata* and *Clarias batrachus* in community fish refuges and Tonle Sap Lake, Pursat Province. *Cambodian Journal of Natural History*, **2016**, 135.

Fish diversity, biomass and survival rates in rice field refuge ponds during the dry season in Pursat Province

VANN Chanmunny

មូលន័យសង្ខេប

ស្រះជម្រកត្រីតាមវាលស្រែដើរតួនាទីយ៉ាងសំខាន់ក្នុងការបង្កើនផលិតផលត្រីក្នុងប្រទេសកម្ពុជា ជាពិសេសក្នុងរដូវប្រាំង។ ការសិក្សារបស់ខ្ញុំបានធ្វើឡើងនៅក្នុងសហគមន៍ស្រះជម្រកត្រីចំនួនបី ក្នុងស្រុកក្រគរ(សហគមន៍ស្រះជម្រកត្រីដំណាក់ក្រាញ់) ស្រុកបាកាន (សហគមន៍ស្រះជម្រកត្រីអារ៉ែន និង សហគមន៍ស្រះជម្រកត្រីត្រាំសេះ) ក្នុងខេត្តពោធិ៍សាត់ ឆ្នាំ២០១៥។ គោលបំណងនៃការសិក្សាមាន៖ ១)ជីវចម្រុះត្រី និង ចំនួននៃប្រភេទត្រីនីមួយៗក្នុងស្រះជម្រកត្រីតាមវាលស្រែ ២)ទិន្នផល និង ជីវម៉ាសរបស់ត្រីនៅក្នុងស្រះជម្រកត្រីតាមវាលស្រែ និង ៣)អត្រានៅរស់របស់ត្រីដែលបានប្រលែងទៅក្នុងស្រះជម្រកត្រីវិញកំឡុងរយៈពេលបីខែក្នុងរដូវប្រាំង។ ស្រះជម្រកត្រីតាមវាលស្រែចំនួនបីត្រូវបានជ្រើសរើសដើម្បីធ្វើការប្រមូលសំណាក។ ត្រីទាំងអស់ត្រូវបានចាប់ និង វាស់វែងប្រវែងសរុប(total length) ប្រវែងចាប់ពីឆែកនៃកន្ទុយមកក្បាល(fork length) និង ប្រវែងស្តង់ដារ(standard length) និង ថ្លឹងទម្ងន់។ ចំនួននៃប្រភេទ និងចំនួនឯកកត្តនៃប្រភេទត្រីនីមួយៗត្រូវគណនា និង ជីវចម្រុះរបស់ត្រីត្រូវបានវិភាគដោយប្រើប្រាស់ សន្ទស្សន៍នៃជីវចម្រុះ(Shannon-Weiner និង Simpson index)។ ម៉ូដែលrandom-effects ត្រូវបានប្រើដើម្បីធ្វើការប្រៀបធៀបរវាងត្រីមុន និង ក្រោយពេលប្រលែង ហើយអត្រានៅរស់បន្ទាប់ពីប្រលែងត្រូវបានគណនា។

ចំនួនត្រីសរុបចំនួន១៦៨៥៦ក្បាល តំណាងឲ្យត្រី២៩ប្រភេទ ២៣ពូកនិង១២អំបូរត្រូវបានចាប់ពីស្រះជម្រកត្រីចំនួន៩ ក្នុងកំឡុងពេលសិក្សា។ ប្រភេទត្រីដែលសម្បូរជាងគេគឺ *Esomus metallicus Trichopodus microlepis Anabas testudineus* និង *Channa striata*។ ពីរប្រភេទខាងចុងជាត្រីដែលមានតម្លៃសេដ្ឋកិច្ចខ្ពស់។ ទិន្នផលត្រីនៃស្រះជម្រកត្រីតាមវាលស្រែគឺប្រមាណជា ២៩.៧៥± ២២.២១គ.ក្រ/រដូវប្រាំង។ ឯកកត្តទាំងអស់នៃប្រភេទត្រីដែលបានប្រលែងទៅក្នុងស្រះ (*A. testudineus C. batrachus* និង *C. striata*) នៅមានទំហំតូច និង មិនទាន់ពេញវ័យនៅឡើយ ក្នុងដំណាក់កាលចុងក្រោយនៃការសិក្សា។ ការកើនទម្ងន់ត្រូវបានស្តែងឡើងចំពោះ *C. batrachus* ប៉ុន្តែមិនមានឃើញចំពោះ *A. testudineus* និង *C. striata* ទេ។ អត្រានៅរស់របស់ត្រីគឺប្រមាណជា ៥៦.៦±២២.៩% សម្រាប់ *A. testudineus* ៦១.៤±២៥.២% សម្រាប់ *C. batrachus* និង ៥២.៣±១៨.០០% សម្រាប់ *C. striata* ។

Abstract

Refugial ponds in rice fields play an important role in fish production in Cambodia, particularly during the dry season. My study was conducted at three community fish refuges in the Krakor (Damnak Kranh) and Bakan (Aren and Tram Sea) districts of Pursat Province in 2015 and aimed to determine: 1) fish diversity and abundance in rice field refuge ponds; 2) fish yield and biomass in rice field refuge ponds; and, 3) the survival rate of stocked fish over three months in the dry season. Three rice field ponds were selected in each refuge for sampling. Fish inhabiting these were caught and identified following measurement of total length, fork length, standard length and weight. Numbers of species and individuals were calculated and species diversity was measured using the Shannon-Weiner index and Simpson index. A random-effects model was used for comparisons before and after stocking and survival rates were calculated for each of the fish species stocked.

A total of 16,856 individuals representing 29 species in 23 genera and 12 families were caught from the nine refuge ponds sampled during the study. The most common fish species were *Esomus metallicus*, *Trichopodus microlepis*, *Anabas testudineus*, and *Channa striata*. The latter two species are of high economic value. The productivity of refuge ponds was estimated as 29.75 ± 22.12 kg/season during the dry season. All individuals of fish species released into the ponds (*A. testudineus*, *C. batrachus* and *C. striata*) remained small and in a juvenile stage at the end of the study. Weight gains were noticeable in *C. batrachus*, but not in *A. testudineus* and *C. striata*. Survival rates were estimated as 56.6% ± 22.9% for *A. testudineus*, 61.4% ± 25.2% for *C. batrachus*, and 52.3% ± 18% for *C. striata*.

Citation: Vann C. (2016) Fish diversity, biomass and survival rates in rice field refuge ponds during the dry season in Pursat Province. *Cambodian Journal of Natural History*, **2016**, 136.

Recent literature from Cambodia

This section summarizes recent scientific publications concerning Cambodian biodiversity and natural resources. The complete abstracts of most articles are freely available online (and can be found using Google Scholar or other internet search engines), but not necessarily the whole article. Lead authors may be willing to provide free reprints or electronic copies on request and their email addresses, where known, are included in the summaries below.

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New species & taxonomic reviews

Bayarsaikhan, U. & Bae Y.S. (2016) A review of the genus *Cyana* Walker, 1854 (Lepidoptera, Erebidae, Arctiinae) from Cambodia, with description of new species. *Zootaxa*, **4114**, 447–463.

A systematic review of *Cyana* moths in Cambodia. Seventeen species are recognized, including seven new country records and one new species to science: *Cyana angkorensis*. A key to Cambodian species within the genus is included with illustrations of adults and genitalia. Author: uug228@yahoo.com

Bayarsaikhan, U. & Bae Y.S. (2016) Review of the genus *Chrysoscota* in Cambodia (Lepidoptera, Erebidae, Arctiinae), with description of a new species. *Zootaxa*, **4154**, 485–488.

A systematic review of the moth genus *Chrysoscota* in Cambodia. A checklist is provided for the genus, which includes one new country record (*C. cotriangulata*) and one new species to science (*Chrysoscota kimsuni*). Descriptions are provided for both species, including illustrations of adults and genitalia. Author: uug228@yahoo.com

Gale, S.W., Schuiteman, A., Watthana, S., Sando, T., Souvannakhoummane, K., Averyanov, L. & Suddee, S. (2016) Studies in Asian *Nervilia* (Nervilieae, Epidendroideae, Orchidaceae) VI: *N. mekongensis*, a new species from Thailand, Cambodia, Laos and Vietnam. *Phytotaxa*, **247**, 267–273.

Describes a new species of the terrestrial orchid genus *Nervilia* from material collected at several localities in the Greater Mekong region of Southeast Asia, including eastern Cambodia. Despite being superficially similar to *N. aragoana*, a widespread species of tropical Asia and Australasia, the new species is most closely affiliated to *N. fordii*, a species known from southern China and Thailand. Taxonomic notes and a conservation assessment are included. Author: stephangale@kfbg.org

Heppner, J.B. & Bae Y.S. (2016) Two new species of *Loboschiza* from Cambodia and Vietnam (Lepidoptera: Tortricidae: Olethreutinae: Enarmoniini). *Zootaxa*, **4169**, 171–178.

Two new species of *Loboschiza* to science are described and illustrated: *L. cambodiensis* from Cambodia and *L. flavobasis* from Vietnam. The two new species bring the number of species described in the genus to 19. Author: jheppner@flmnh.ufl.edu

Kosterin, O.E. (2016) *Microgomphus alani* (Odonata, Gomphidae) sp. nov. from Cambodia. *Zootaxa*, **4114**, 341–350.

Describes a new species of dragonfly to science from male specimens collected in the coastal foothills of the Cardamom Mountains in Koh Kong Province. Females believed to be the same species were previously reported from Phrae Province in northern Thailand. Author: kosterin@bionet.nsc.ru

Kosterin, O.E. (2016) Reconsideration of the genera *Merogomphus* Martin, 1904, and *Anisogomphus* Selys, 1857, including erection of a new genus, with a new species and discussion of additional specimens from Cambodia. *Zootaxa*, **4171**, 51–76.

A systematic revision of the Odonata genus *Merogomphus*, including the description of a new species to science from Cambodia: *Euthygomphus schorri*. The type locality of the new species is near Sen Monorom in Mondulkiri Province. Author: kosterin@bionet.nsc.ru

Souladeth, P., Prajaksood, A., Parnell, J.A.N. & Newman, M.F. (2016) Typification of names *Eriocaulon* in the flora of Thailand and flora of Cambodia, Laos and Vietnam. *Edinburgh Journal of Botany.* doi:10.1017/S0960428616000238

This paper designates lectotypes for eight names in *Eriocaulon* in tropical Asia, namely *E. alatum*, *E. hamiltonianum*, *E. hookerianum*, *E. infirmum*, *E. lanigerum*, *E. nautiliforme*, *E. nigrum,* and *E. ubonense*. Additional information on the lectotype of *E. quinquangulare* is given. Author: p.souladeth@nuol.edu.la

Tanaka N., Tagane S., Chhang P. & Yahara T. (2015) A purple flowered new *Globba* (Zingiberaceae), *G. bokorensis*, from southern Cambodia. *Bulletin of the National Museum of Nature and Science Series B (Botany),* **41**, 155–159.

A new plant species to science is described from Bokor National Park. The new species is related to *Globba*

leucantha, but is distinguished by glabrous lamina, a wholly purple inflorescence and flowers and longer anther crests. Author: nobuyuki_tanaka@kahaku.go.jp

Toyama H., Tagane S., Chhang P., Nagamasu H. & Yahara T. (2016) Flora of Bokor National Park, Cambodia III: a new species, *Garcinia bokorensis* (Clusiaceae). *Acta Phytotaxonomica et Geobotanica*, **67**, 47–53.

This study describes a new species of *Garcinina* (Clusiaceae) to science from Bokor National Park with illustrations and photographs. An updated identification key for species of *Garcinina* section *Oxycarpus* in Indochina is also provided. Author: htohyscb@kyushu-u.org

Toyama H., Tagane S., Chhang P., Nagamasu H. & Yahara T. (2016) Flora of Bokor National Park, Cambodia IV: a new section and species of *Euphorbia* subgenus *Euphorbia*. *Acta Phytotaxonomica et Geobotanica*, **67**, 83–96.

Paper not seen. Author: htohyscb@kyushu-u.org

Yahara T., Tagane S., Mase K., Chhang P. & Toyama H. (2016) Flora of Bokor National Park V: two new species of *Machilus* (Lauraceae), *M. bokorensis* and *M. brevipaniculata*. *PhytoKeys*, **65**, 35–46.

Two new species of *Machilus* (Lauraceae) to science are described with illustrations and photographs from Bokor National Park. Author: stagane29@gmail.com

Biodiversity inventories

Goes, F. (2016) *Cambodia Quarterly Bird Reports, April–June 2014*. Http://www.samveasna.org/userfiles/cambodia_quarterly_bird_reports__april-june_2014.pdf [accessed 28 November 2016].

Goes, F. (2016) *Cambodia Quarterly Bird Reports, July–September 2014*. Http://www.samveasna.org/userfiles/cambodia_quarterly_bird_reports__july-september_2014.pdf [accessed 28 November 2016].

Goes, F. (2016) *Cambodia Quarterly Bird Reports, October–December 2014*. Http://www.samveasna.org/userfiles/cambodia_quarterly_bird_reports__october-december_2014.pdf [accessed 28 November 2016].

Part of a continuing series of quarterly reports, compiling bird counts and unusual records across Cambodia. Author: fredbaksey@yahoo.com

Lee S., Duwalb, R.K. & Lee W. (2016) Diversity of stingless bees (Hymenoptera, Apidae, Meliponini) from Cambodia and Laos. *Journal of Asia-Pacific Entomology*, **19**, 947–961.

Stingless bees are restricted to the tropical regions of the world and are important pollinators of various wild and cultivated plants. This study recognizes 14 species of stingless bees in the dry season from Cambodia and Laos, three of which are first records for Cambodia: *Pariotrigona pendleburyi*, *Tetragonula sirindhornae*, and *Tetrigona melanoleuca*. Images of morphology, nesting behaviour, and a checklist of stingless bees in Cambodia and Laos are provided. Authors: seung@snu.ac.kr, ramkeshariduwal@gmail.com

Mahood, S. (2016) Chestnut-cheeked starling *Agropsar philippensis*: first unequivocal record for Cambodia. *BirdingASIA*, **25**, 118–119.

This note confirms the occurrence of chestnut-cheeked starling in Cambodia (the only previous record being of a captive bird of unknown provenance) and is based on observations of the species in Phnom Penh in February 2016. Author: smahood@wcs.org

Mahood, S. (2016) The first documented record of northern boobook *Ninox japonica* in Cambodia. *BirdingASIA*, **25**, 119–120.

This note documents the first country record of northern boobook and is based on a single bird incidentally caught and subsequently released in Phnom Penh in March 2013. Author: smahood@wcs.org

McCann, G.E. (2016) Marbled cat *Pardofelis marmorata* at Virachey National Park, Ratanakiri, Cambodia. *Southeast Asia Vertebrate Records*, **2016**, 72–74.

This note documents a camera trap record of a single marbled cat on the summit of Phnom Haling in Virachey National Park in January 2016. Author: greg.mccann1@gmail.com

Nuttall, M., Willcox, D., Nut M., Seng R. & Handschuh, M. (2016) The first records of red-legged crake *Rallina fasciata* for Cambodia. *BirdingASIA*, **25**, 114–115.

This note documents the first records of red-legged crake in Cambodia from three protected areas in August 2010 and July and November 2013. Author: mnuttall@wcs.org

Seehausen, M., Constant, J. & Smets, K. (2016) On a collection of Odonata from Cambodia, with the first record of *Sinictinogomphus clavatus* and a description of the female of *Zyxomma breviventre*. *Notulae odonatologicae*, **8**, 203–245.

This study documents 22 species of Odonata from collections made in Cambodia in May 2003. These include the first country record of *Sinictinogomphus clavatus.* Author: malte.seehausen@museum-wiesbaden.de

Species ecology & status

Barca, B., Vincent, C., Soeung K., Nuttall, M. & Hobson, K. (2016) Multi-female group in the southernmost species of *Nomascus*: field observations in eastern Cambodia reveal multiple breeding females in a single group of southern yellow-cheeked crested gibbon *Nomascus gabriellae*. *Asian Primates Journal*, **6**, 15–19.

Field studies of *Nomascus* gibbons have shown that multi-female polygynous groups are quite common in

the northernmost species. Based on research in Seima (Mondulkiri Province), this study shows that multi-female groups are also present in the southernmost species: *N. gabriellae*. Author: benbarca88@gmail.com

Furey, N.M., Whitten, T., Cappelle, J. & Racey, P.A. (2016) The conservation status of Cambodian cave bats. In *International Speleological Project to Cambodia 2016 (Provinces of Stoeng Treng, Kampong Speu, Banteay Meanchey and Battambang)* (ed M. Laumanns), pp. 82–95. Berliner Höhlenkundliche Berichte, 64, Berlin, Germany.

This review describes the conservation status of cave-roosting bats in Cambodia based on rapid surveys of 98 caves in the Kampot, Kep, Battambang and Stung Treng provinces between 2014 and 2016. Most of the caves surveyed supported a relatively depauperate bat fauna, although repeated surveys would likely reveal additional species and individuals at some sites. Thirteen caves of national significance for bat conservation are identified. Author: neil.m.furey@gmail.com

Gonzalez-Monge, A. (2016) The socioecology, and the effects of human activity on it, of the Annamese silvered langur (*Trachypithecus margarita*) in northeastern Cambodia. PhD thesis, Australian National University, Canberra, Australia.

The effects of human disturbance on langurs are unknown, a reason for concern given the current biodiversity crisis in Southeast Asia. This study explores the socioecology of the Annamese silvered langur and effects of human disturbance on the species in Veun Sai–Siem Pang National Park, Ratanakiri Province. Langurs were strongly affected by logging, moving higher in the canopy as logging intensity increased, and abandoned areas of their home range where it was most destructive. The study concludes that while the langur tolerates some human disturbance, law enforcement must be maintained at the site.

Hon N. (2016) *Food selection by northern yellow-cheeked crested gibbons (*Nomascus annamensis*) in northern Cambodia*. MSc thesis, Victoria University of Wellington, New Zealand.

This study quantifies food selection by northern yellow-cheeked crested gibbons in northern Cambodia by investigating the main plant species consumed and the influence of the availability of food items on their selection. It also explores the nutritional composition of food items consumed by the species and identifies plant species that provide significant nutrients. Author: navenhon@yahoo.com

Kidney, D., Rawson, B.M., Borchers, D.L., Stevenson, B.C., Marques, T.A. & Thomas, L. (2016) An efficient acoustic density estimation method with human detectors applied to gibbons in Cambodia. *PLoS ONE*, **11**, e0155066. doi:10.1371/journal.pone.0155066

Animal species such as gibbons are hard to see but easy to hear. Standard visual methods for estimating population density for these species are often ineffective or inefficient, but methods based on passive acoustics show promise. This article presents a spatially explicit capture-recapture method for territorial vocalising species, where humans act as acoustic detectors. The results suggest that the method provides reliable density estimates for gibbons and is efficient because it only requires routine survey data. Author: darrenkidney@googlemail.com

Wilcox, D., Visal S. & Mahood, S.P. (2016) The conservation status of otters in Prek Toal Core Area, Tonle Sap Lake, Cambodia. *IUCN Otter Specialist Group Bulletin*, **33**, 18–31.

Identification and protection of sites that support sizeable populations of otters in Southeast Asia is important because regional populations face many threats and are declining. This study presents the results of a rapid camera trap survey in 2014 along one stream in the Prek Toal Core Area, an area of flooded forest in Tonle Sap Lake. Thirty-four photographs were obtained of otters, 24 of which could be identified as smooth-coated otter and four as hairy-nosed otter. Author: smahood@wcs.org

Coasts, wetlands and aquatic resources

Chap S., Touch P. & Diepart, J.-C. (2016) *Fisheries Reforms and Right-based Fisheries: Insights from Community Fisheries across Cambodia*. The Learning Institute, Phnom Penh, Cambodia.

This working paper uses a right-based approach to examine the recent wave of reforms in the Cambodian fisheries sector and what these reforms mean for community fisheries management.

Kong S. (2016) *An estimation of the production function of fisheries in Peam Krasaob Wildlife Sanctuary in Koh Kong Province, Cambodia*. EEPSEA Research Report, Economy and Environment Program for Southeast Asia, Philippines.

This report presents an economic analysis of the different uses and values of mangroves in supporting nurseries and breeding grounds for commercially important finfish in the Koh Kong, Kep, Kampot, and Preah Sihanouk provinces. Results show that direct and indirect values derived from mangrove forests are very high and that failure to conserve mangroves will result in serious or irreversible ecological degradation and substantial economic losses. Author: kong.sopheak@rupp.edu.kh

Pervin, R. (2016) *Identifying changes in mangroves in Trat Province, Thailand and Koh Kong Province, Cambodia*. MSc thesis, San Francisco State University, California, USA.

This study explores changes in the extent of mangroves from 1996 to 2015 in the coastal areas of Trat Province,

Thailand and Koh Kong Province, Cambodia. Results indicate that mangroves decreased from 7.5% to 27.8% over this period in both areas, although they increased by 7.7% in Koh Kong between 2009 and 2015.

Sáenz, L., Farrell, T., Olsson, A., Turner, W., Mulligan, M., Acero, N., Neugarten, R., Wright, M., McKinnon, M., Ruiz, C. & Guerrero, J. (2016) Mapping potential freshwater services, and their representation within Protected Areas (PAs), under conditions of sparse data. Pilot implementation for Cambodia. *Global Ecology and Conservation*, **7**, 107–121.

Little is known about the effectiveness of conservation responses such as protected areas (PAs) in protecting freshwater ecosystems and their services. This paper proposes a freshwater services metrics framework to quantify the representation of freshwater services in PAs and pilots this in Cambodia. Results indicate that conservation actions have more effectively represented freshwater regulation services than freshwater provisioning services, with major rivers remaining generally unprotected. Author: lsaenz@conservation.org

Savage, J.M., Osborne, P.E. & Hudson, M.D. (2016) Effectiveness of community and volunteer based coral reef monitoring in Cambodia. *Aquatic Conservation: Marine and Freshwater Ecosystems.* doi:10.1002/aqc.2690

This study investigates the ability of surveyors with different levels of experience to conduct underwater surveys using a simple coral reef survey methodology. Results indicate that experience, rather than cultural background, influences survey ability and thus suggest that locally based programmes can fill gaps in knowledge with suitable training and assessment. Author: j.savage@soton.ac.uk

Tangdamrongsub, N., Ditmar, P.G., Steele-Dunne, S.C., Gunter, B.C. & Sutanudjaja, E.H. (2016) Assessing total water storage and identifying flood events over Tonlé Sap basin in Cambodia using GRACE and MODIS satellite observations combined with hydrological models. *Remote Sensing of Environment*, **181**, 162–173.

This article uses a variety of remote sensing and hydrological data to generate monthly and sub-monthly terrestrial water storage estimates and quantify flood events in the Tonle Sap basin between 2002 and 2014. Results suggest that the apporoach is an effective tool for monitoring small-scale (82,000 km^2) hydrological basins. Author: N.Tangdamrongsub@tudelft.nl

Forests and forest resources

Chassagne, F., Hul S., Deharo, E. & Bourdy, G. (2016) Natural remedies used by Bunong people in Mondulkiri province (Northeast Cambodia) with special reference to the treatment of 11 most common ailments. *Journal of Ethnopharmacology*, **191**, 41–70.

This paper investigates traditional knowledge about natural medicine (plants, animals, and mushrooms) in Cambodia's largest indigenous community. Bunong people in Mondulkiri Province use a total of 214 plants, one mushroom, and 22 animal species in their traditional practices to treat 51 different ailments. Most of the species reported for the treatment of the 11 most frequent ailments have already been proven to be efficient and safe. While undergoing considerable changes, Bunong people retain extensive traditional medicine knowledge and depend mainly on natural remedies for their healthcare. Author: francois.chassagne@ird.fr

Mermoz, S. & Thuy L.T. (2016) Forest disturbances and regrowth assessment using ALOS PALSAR data from 2007 to 2010 in Vietnam, Cambodia and Lao PDR. *Remote Sensing*, **8**, 217. doi:10.3390/rs803021

The deforestation rate in Vietnam is among the highest in the tropics in recent decades and is also increasing rapidly in Cambodia and Laos. This paper develops a new methodology for monitoring forest disturbances and regrowth using ALOS PALSAR data in tropical regions. The results indicate disturbance rates of −1.07% in Vietnam, −1.22% in Cambodia, and −0.94% in Laos between 2007 and 2010, with corresponding aboveground biomass losses of 60.7 T*g*, 59.2 T*g* and 83.8 T*g*, respectively.

Monda Y., Ito E., Kiyono Y., Sato T., Toriyama J., Sokh H., Chann S., Tith B., Keth S., Phallaphearaoth O. & Bounthabandid, S. (2016) Allometric equations for tropical seasonal deciduous forests in Cambodia: a method of estimating belowground tree biomass with reduced sampling loss of roots. *Japan Agricultural Research Quarterly*, **50**, 369–377.

Appropriate and simple methods of estimating the biomass of tropical seasonal forests in central Indochina, such as allometric equations, are needed to support initiatives such as REDD+. This study destructively sampled 28 trees in a deciduous forest in Kratie Province, and develops new allometric equations for estimating the tree-level biomass of aboveground woody parts, leaves, total aboveground parts, and belowground parts. A new sampling method is also presented to reduce sampling loss of belowground parts. Author: monda.yukako.2m@kyoto-u.ac.jp

Sasaki N., Chheng K., Mizoue N., Abe I. & Lowe, A.J. (2016) Forest reference emission level and carbon sequestration in Cambodia. *Global Ecology and Conservation*, **7**, 82–96.

Adoption of the Paris Agreement suggests that developing countries urgently need to establish a forest reference emission level (FREL) if they wish to seek financial support to reduce carbon emissions from deforestation and forest degradation. This study analyzes forest

cover and carbon stock changes for seven forest types in Cambodia between 2002 and 2006 and estimates stocks in four carbon pools (aboveground, belowground, litter, and deadwood pools). Author: nopheas@ait.asia

Singh, M., Evans, D., Coomes, D.A., Friess, D.A., Suy T.B. & Samean N.C. (2016) Incorporating canopy cover for airborne-derived assessments of forest biomass in the tropical forests of Cambodia. *PLoS ONE*, **11**, e0154307. doi:10.1371/journal.pone.0154307

This study examines the role of canopy cover in influencing above ground biomass (AGB) dynamics of an open canopied forest and evaluates the efficacy of individual-based and plot-scale height metrics in predicting AGB variation in the tropical forests of Angkor Thom, Cambodia. Author: ms2127@cam.ac.uk

Toyama H., Kajisa T., Tagane S., Mase K., Chhang P., Samreth V., Ma V., Sokh H., Ichihasi R., Onoda Y., Mizoue N. & Yahara T. (2015) Effects of logging and recruitment on community phylogenetic structure in 32 permanent forest plots of Kampong Thom, Cambodia. *Philosophical Transactions of the Royal Society B: Biological Sciences*, **370**, 20140008. doi:10.1098/rstb.2014.0008.

This paper explores the effects of logging, mortality and recruitment of trees on phylogenetic community structure in 32 plots in primary evergreen forest and secondary dry deciduous forest in Kampong Thom Province. Within communities, logging decreased phylogenetic diversity, and increased overall phylogenetic clustering and terminal phylogenetic evenness. Between communities, logging increased phylogenetic similarity between evergreen and deciduous plots. Recruitment had opposite effects. Author: htohyscb@kyushu-u.org

Yeang D., Eam S.U., Shercan, K. & McKerrow, L. (2016) *Local community participation in biodiversity monitoring and its implication for REDD+: a case study of Changkran Roy Community Forest in Cambodia*. The 7th International Conference on Environment and Rural Development, Phnom Penh, Cambodia.

A significant part of the Reducing Emissions from Deforestation and Forest Degradation (REDD+) scheme depends on the participation of local communities in monitoring carbon and biodiversity. This paper presents evidence on how local communities are engaging in monitoring activities at a community forest in Siem Reap Province and concludes that this approach is important to engage and empower local community members in REDD+. Author: yeangdonal@gmail.com

Zhang M., Tagane S., Toyama H., Kajisa T., Chhang P. & Yahara T. (2016) Constant tree species richness along an elevational gradient of Mt. Bokor, a table-shaped mountain in southwestern Cambodia. *Ecological Research*, **31**, 495–504.

Previous research on tropical mountains has suggested that plant species richness declines with increasing elevation. This study determined tree species richness along an elevational gradient on Mt. Bokor and explores relationships between species richness and environmental factors. Unlike previous studies, tree species richness was nearly constant along the elevation gradient where temperature and precipitation were expected to vary. Author: tet.yahara@gmail.com

Environmental policy & practice

Baird, I.G. (2016) Non-government organizations, villagers, political culture and the Lower Sesan 2 dam in northeastern Cambodia. *Critical Asian Studies*, **48**, 257–277.

As the largest dam to ever be built in Cambodia, the Lower Sesan 2 (LS2) project is expected to cause serious environmental and social impacts. This article analyzes relationships between Cambodian NGOs and villagers that will be negatively impacted by the LS2, as well as relations between NGOs and the Cambodian state. It suggests that while development actors often attempt to construct narratives to control development trajectories, such attempts can meet with resistance from local people, even when facing powerful opponents. Author: ibaird@wisc.edu

Walther, B.A., Boëte, C., Binot, A., By Y., Cappelle, J., Carrique-Mas, J.J., Chou M., Furey, N., Kim S., Lajaunie, C., Lek S., Méral, P., Neang M., Tan B-H., Walton, C. & Morand, S. (2016) Biodiversity and health: lessons and recommendations from an interdisciplinary conference to advise Southeast Asian research, society and policy. *Infection, Genetics and Evolution*, **40**, 29–46.

Southeast Asia is an economic, biodiverse, cultural and disease hotspot. Due to rapid socio-economic and environmental changes, the role of biodiversity and ecosystems for human health ought to be examined and communicated to decision-makers and the public. This review paper summarizes the lessons and recommendations from an interdisciplinary conference convened in Cambodia in 2014 to advise Southeast Asian societies on current research efforts, future research needs, and to provide suggestions for improved education, training and science–policy interactions. Case-studies from Cambodia are included. Author: bawalther2009@gmail.com

The Recent Literature section was compiled by Neil M. Furey, with contributions from Tagane Shuichiro.

Instructions for Authors

Purpose and Scope

The *Cambodian Journal of Natural History* (ISSN 2226–969X) is an open access, peer-review journal published biannually by the Centre for Biodiversity Conservation at the Royal University of Phnom Penh. The Centre for Biodiversity Conservation is a non-profit making unit, dedicated to training Cambodian biologists and the study and conservation of Cambodia's biodiversity.

The *Cambodian Journal of Natural History* publishes original work by:

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- Cambodian scientists on studies of natural history in any part of the world.

The Journal especially welcomes material that enhances understanding of conservation needs and has the potential to improve conservation management in Cambodia. The primary language of the Journal is English. For full papers, however, authors are encouraged to provide a Khmer translation of their abstract.

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- News (<300 words)
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- Research on the status or ecology of habitats.
- Checklists of species, whether nationally or for a specific area.
- Discoveries of new species records or range extensions.
- Reviews of conservation policy and legislation in Cambodia.
- Conservation management plans for species, habitats or areas.
- The nature and results of conservation initiatives, including case studies.
- Research on the sustainable use of wild species.

The Journal does not normally accept formal descriptions of new species, new subspecies or other new taxa. If you wish to submit original taxonomic descriptions, please contact the editors in advance.

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Concise reports (<300 words) on news of general interest to the study and management of Cambodia's biodiversity. News items may include, for example:

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Authors should consult previous issues of the journal for general style, and early-career authors are encouraged to consider guidance provided by:

Fisher, M. (2012) Editorial – To shed light on dark corners. *Cambodian Journal of Natural History*, **2012**, 1–2.

Daltry, J., Fisher, M. & Furey, N.M. (2012) Editorial – How to write a winning paper. *Cambodian Journal of Natural History*, **2012**, 97–100.

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The following are examples of house style:

Papers:

Berzins, B. (1973) Some rotifers from Cambodia. *Hydrobiologia,* **41,** 453-459.

Neang T. (2009) Liquid resin tapping by local people in Phnom Samkos Wildlife Sanctuary, Cambodia. *Cambodian Journal of Natural History,* **2009,** 16-25.

Tanaka S. & Ohtaka A. (2010) Freshwater Cladocera (Crustacea, Branchiopoda) in Lake Tonle Sap and its adjacent waters in Cambodia. *Limnology,* **11,** 171-178.

Books and chapters:

Khou E.H. (2010) *A Field Guide to the Rattans of Cambodia.* WWF Greater Mekong Cambodia Country Programme, Phnom Penh, Cambodia.

MacArthur, R.H. & Wilson, E.O. (1967) *The Theory of Island Biogeography*. Princeton University Press, Princeton, USA.

Rawson, B. (2010) The status of Cambodia's primates. In *Conservation of Primates in Indochina* (eds T. Nadler, B. Rawson & Van N.T.), pp. 17-25. Frankfurt Zoological Society, Frankfurt, Germany, and Conservation International, Hanoi, Vietnam.

Reports:

Lic V., Sun H., Hing C. & Dioli, M. (1995) *A brief field visit to Mondolkiri Province to collect data on kouprey* (Bos sauveli*), rare wildlife and for field training.* Unpublished report to Canada Fund and IUCN, Phnom Penh, Cambodia.

Theses:

Yeang D. (2010) *Tenure rights and benefit sharing arrangements for REDD: a case study of two REDD pilot projects in Cambodia*. MSc thesis, Wageningen University, Wageningen, The Netherlands.

Websites:

IUCN (2010) 2*010 IUCN Red List of Threatened Species.* Http://www.redlist.org [accessed 1 December 2010].

About the Author(s): This section is optional for Full Papers and Short Communications. It should describe the main research interests of each author (<150 words each), apart from what is obvious from the subject of the manuscript and the authors' affiliations.

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The Editors are grateful to our reviewers and to Regine Weckauf, Sam Leslie, Marianne Teoh and Kate West for their kind assistance with the production of this issue.

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